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THE FORMATION OF INTUMESCENCES ON POTATO PLANTS[1]

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(WITH NINE FIGURES)

During the winter of 1904–5, in some experiments to determine the relation of a soil fungus to potato plants, Professor ATKINSON planted some potatoes in pots, and after the young shoots were well started they were covered with bell jars to produce a moist atmosphere, which would be more favorable for the growth of the fungus. In a few days intumescences were formed in great numbers, so that a large part of the plant was literally covered with them. This suggested that the potato plant would be an excellent subject with which to experiment to determine the cause of the formation of these intumescences, at least under certain conditions. The matter was then placed in my hands for this purpose. The subject was the more interesting because of the difference of opinion among plant physiologists as to the influence of light stimulus in the formation of intumescences upon plants, as pointed out by VON SCHRENK (9) in his paper on "Intumescences formed as the result of chemical stimulation."

The methods used in the experiments for producing the intumescences were in general as follows: young plants were covered with bell jars and their roots supplied every day with an abundance of warm water, except in those experiments where the roots were kept cold. The absorption of water was thus very great, while the saturated air under the bell jar greatly checked the transpiration.

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For the purpose of experiment, the light and temperature conditions could be easily changed.

The intumescences were formed very quickly, generally within two to five days after covering the plants. Usually they appeared on the upper side of the leaf, but were observed also, in cases where they were very abundant, on the under side and scattered profusely over the upper part of the stem. They did not form on the very young growing leaves at the tip of the stem and rarely on the two mature lower leaves of the shoot. The appearance of these intumescences was very similar to that described by VON SCHRENK (9) on the cauliflower. To the naked eye they first appeared as very small greenish-yellow dots, projecting slightly from the surface of the leaf. These rapidly developed in size, became lighter yellow, hemispherical, smooth, and glossy. After about twenty-four hours they became whitish and roughened, and projected prominently from the surface. Usually the central part of the intumescence was slightly yellowish in color, with a ring of more whitish cells around the outside. When they first appeared, the intumescences came out over or near the main veins; but when very numerous, they broke out all over the surface of the leaf and looked very much like incrustations of some crystalline salt. The affected leaves curled over toward the under side, and this curling became the stronger the more intumescences were produced. The single intumescences were from 2 to 3^{mm} in diameter. When formed numerously, however, the single intumescences often became confluent, making large rough patches. These intumescences lasted but a short time; in a day or two they had collapsed and become dry and blackened. A cross-section through the leaf showed that the intumescences were due to the hypertrophy of the cells lying underneath the epidermis. The swollen cells were first found in the palisade layer; they elongated and pushed against the epidermis; and in most of the cells cross-walls were formed. These cells continued to enlarge until the pressure upon the epidermis caused it to break and the palisade cells to push up through. As the cells enlarged, the chlorophyll granules lost their green color, became yellowish, and disappeared entirely from the cells or remained very much reduced, scattered through the bottom parts.

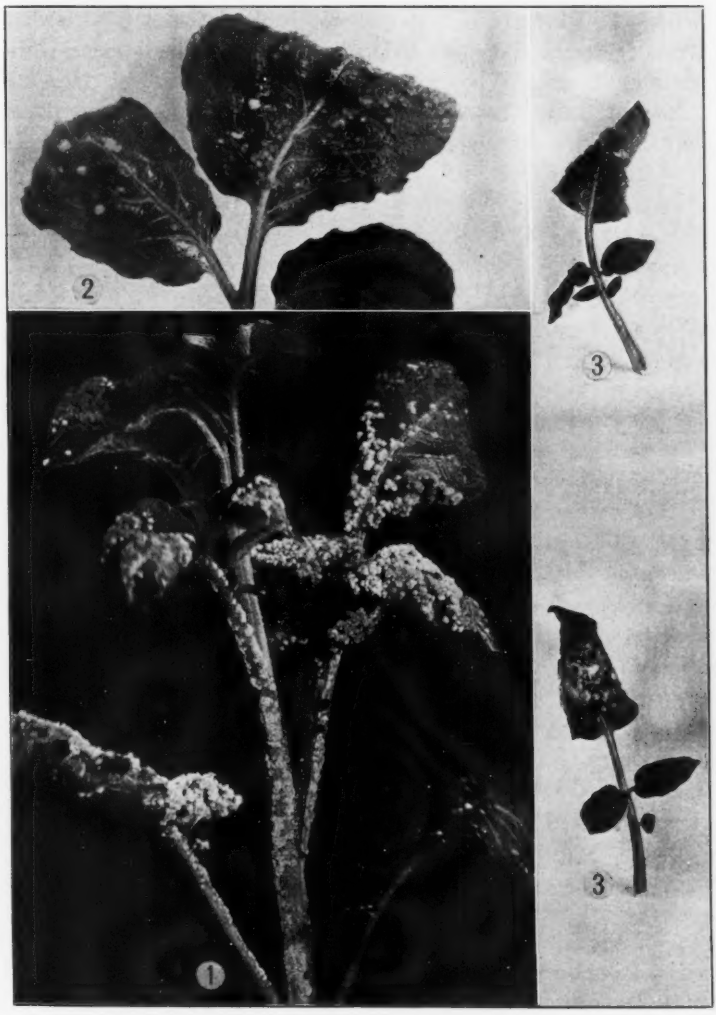

FIG. 1.—Photograph showing intumescences formed on a young potato shoot under whitewashed glass. FIGS. 2, 3.—Intumescences formed on a leaf in sunlight.

After the elongated palisade cells had broken through the epidermis, the pressure against their side walls being thus somewhat relieved, the sac-like cells bulged out laterally and became club-shaped at the tip. The central cells stood up perpendicularly to the surface of the leaf, but the cells around the edge of the intumescences curled over toward the leaf surface, thus causing the outside whitish

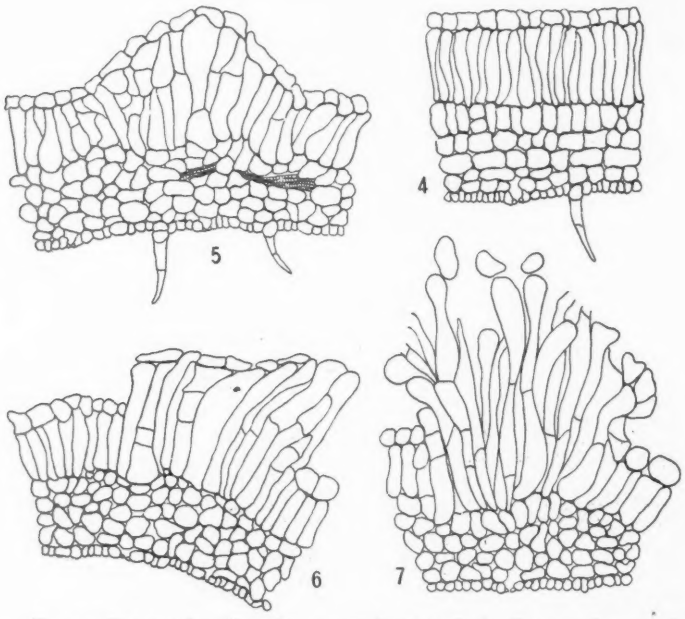

FIG. 4.—Cross-section through a normal potato leaf. FIG. 5.—Cross-section through a young intumescence, showing hypertrophy of palisade layer and formation of cross-walls. FIG. 6.—Later stage; the swollen cells have broken through the epidermis. FIG. 7.—Later stage; some of the cells were cut through in sectioning.

ring of the intumescence, mentioned before. The hypertrophied cells were not confined to the palisade layer, but often included cells in the layer of spongy parenchyma below. In the largest intumescences the swollen cells extended back to one or two rows from the under epidermis. As the intumescences grew old their walls became cutinized.

Intumescences have been observed on various plants by several writers, and all practically agree that they are formed under conditions of excessive humidity accompanied by great warmth. As to

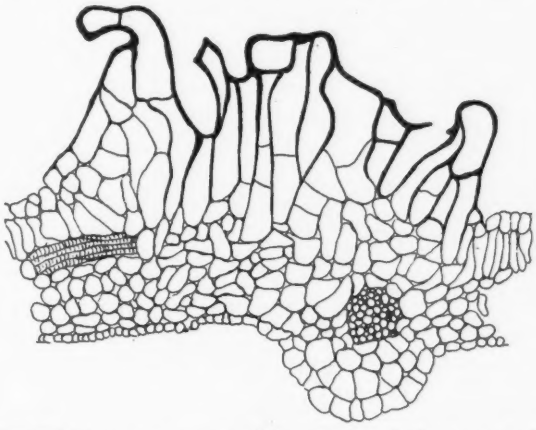

FIG. 8.—Old intumescence; parts of the cells have broken away and the walls have become cutinized.

the presence or absence of a light stimulus, there is a greater difference of opinion. SORAUER (**10–20**), who has described the majority

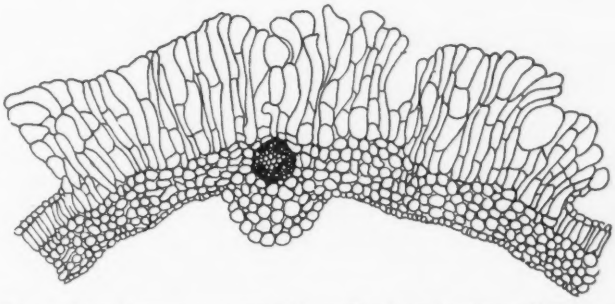

FIG. 9.—Large intumescence or patch formed by the union of several intumescences.

of cases, regards the lack of sufficient light to carry on rapid metabolism as an important factor in their formation. In "Die symptomische Bedeutung der Intumescenzen" (**12**), in which a number of cases

are described, he finds in every case, except one which developed under forced conditions in the greenhouse, that the intumescences were formed in the fall or winter, when the plants were in their rest period or approaching it. On account of the weak illumination during this time, the plants could not assimilate new building material and thus answered the stimulus of an over-abundant absorption of water by the formation of intumescences.

ATKINSON (1) explains the tomato oedema in a similar way. He says: "With the comparatively small amount of light carbon assimilation is lessened, so that the plant, under the forced conditions of growth, when it needs large quantities of carbohydrates, has to do with a really less quantity than is supplied in the open, when conditions for rapid growth are not so favorable and those for assimilation are improved."

KÜSTER (5) produced artificial intumescences on poplar leaves both in the dark and in the light, but found that when formed in intense light they occurred on the surface of the leaf which lay next the water. He suggested that in this case they did not form on the upper side on account of a more rapid transpiration, due to the strong light.

PRILLIEUX (8) observing the disease on pinks and NOACK (7) on grapes found that intumescences were produced only in weak light.

On the other hand, DALE (3) found that intumescences were not easily produced on *Hibiscus vitifolius* in poor light; were not formed under blue or green glass; but develop readily under red, yellow, or whitewashed glass and in bright light.

VIALA and PACOTTET (21) also strongly emphasize the fact that intumescences are only found in quantity on grape leaves directly under the glass, during periods of most brilliant illumination. These they regard as an effort of the plant to protect the leaf from "chlorovaporization and excessive transpiration" by the formation of a false palisade layer.

According to VON SCHRENK (9), intumescences are formed in the Missouri Botanical Garden only under these last-named conditions.

It is a matter of considerable interest, therefore, to determine the conditions under which intumescences are formed in the potato plant.

On March 12, 1906, thirty-six pots of potatoes were planted in

the greenhouse, to be used for the purpose of experiment. Eighteen of the potatoes were planted whole, while in the other pots were placed pieces containing two or three eyes. All of the potatoes were of good size and healthy. By April 4 several shoots had come up some distance from the ground and were covered with the bell jars.

EXPERIMENT I

Four pots of young plants with a few rather small young leaves were placed under bell jars in a well-lighted position in the greenhouse. The temperature of the air within the jars at the time of the setting-up of the experiment was 88° F. For three or four days after it was damp and cold, with only intermittent periods of sunshine. The temperature within the jars averaged about 65° F. In five to six days, after the temperature had increased to 68° F., intumescences began to appear.

Pot 1. Three shoots (from a cut potato), 205,172,128^{mm} high respectively; all had rather small leaves.

Pot 2. Two shoots (from a cut potato), both 62^{mm} high, with young leaves.

Pot 3. One shoot (from a whole potato), 36^{mm} high, with young leaves.

Pot 4. Two shoots (from a whole potato), 32 and 61^{mm} high, with small leaves.

Results

No. 1. After six days intumescences began to appear on all three plants and to assume the characteristic appearance. They were scattered over most of the leaves of the plant and were very numerous on two or three of them. Four days later they had become dry and blackened, but in two days more new ones had appeared.

No. 2. In five days intumescences had appeared on both shoots, although they were rather few and scattered over various leaves.

No. 3. In five days intumescences had formed, but not profusely.

No. 4. In five days a few intumescences had formed.

Intumescences were thus formed upon all of the shoots, but were more numerous on the shoots of pot 1. This was probably due to the fact that these plants were farther developed than the others and consequently did not grow so fast. The other plants were very young and grew rapidly, and in consequence made use of more water in growth than the other shoots. A discussion of the connection between growth and the formation of intumescences will be taken up later in this paper.

EXPERIMENT II

At the same time as the preceding experiment, four plants were placed in darkness. The other conditions of temperature and moisture were the same. The bell jars were covered with black cloth to exclude the light.

Pot 5. One shoot (from a cut potato), 133^{mm} high, with small leaves.

Pot 6. Two shoots (from a cut potato), 80 and 100^{mm} high, with small leaves.

Pot 7. Three shoots (from a whole potato), 84, 63, and 25^{mm} high, with small leaves.

Pot 8. Two shoots (from a whole potato), 63 and 25^{mm} high, with small leaves.

Results

No. 5. In darkness eleven days and no intumescences formed.

No. 6. In darkness eleven days and no intumescences.

No. 7. In darkness eleven days; in six days two or three intumescences were found on one leaf.

No. 8. In darkness eleven days and no intumescences.

These plants were all small and their stems grew very rapidly in the dark. In the three cases where intumescences were not produced, it was thought that this might be due to the rapidity of growth. Accordingly a more developed plant was chosen and placed under the same conditions.

Pot 9. Two shoots (from a whole potato), 105 and 120^{mm} high, with large, well-developed leaves. In two days a few intumescences had formed upon one of the shoots.

It will thus be noted that on two of the plants placed in darkness a few intumescences were formed. It was suggested that this might possibly be due to the fact that the bell jars were not absolutely light tight. Accordingly another pot was placed under the same conditions and the bell jar covered with several thicknesses of cloth to prevent light from filtering through the folds.

Pot 10. Two shoots (from a whole potato), 180 and 96^{mm} high, with large leaves. No intumescences were formed.

These plants, after having been taken from darkness, were left in the light and allowed to develop their leaves. They were then covered with bell jars in the light and after eight days all the shoots, excepting those of pot 10, had developed intumescences.

EXPERIMENT III

The next question which arose was in regard to the effect of increasing the absorption of water by the roots. Pots were placed over the warm water pipes, keeping the soil at a temperature of 70° F. The position of the plant was under whitewashed glass in the greenhouse.

Pot 11. One shoot (from a whole potato), 60^{mm} high, with many large leaves.

Pot 12. Two shoots (from a whole potato), 65 and 60^{mm} high, with many large leaves.

Results

No. 11. After four days many intumescences were produced on many leaves.

No. 12. After four days intumescences formed on nearly all the leaves and were very numerous on some of them. These intumescences continued to appear for several days.

EXPERIMENT IV

Two plants were kept under the same conditions as in the preceding experiment, with the exception of being darkened by covering their bell jars with black cloth.

Pot 13. Two shoots (from a whole potato), 102 and 62^{mm} high, with small leaves.

Pot 14. Two shoots (from a whole potato), 185 and 130^{mm} high, with large leaves.

No intumescences were formed after ten days on either plant; the growth, however, in both cases was very rapid.

EXPERIMENT V

The absorption of water was lessened by keeping the roots cold. Ice was kept packed around the pots, making an average temperature of the soil about 58° F. The pots were cut off from the air above in the bell jar by a thick blotting-paper covering. The air in the bell jars was kept warm by the sun (about 78° F.) during the days while the experiment was going on. A saturated atmosphere was produced within the jars by the evaporation from dishes of water.

In light

Pot. 15. Two shoots (from a cut potato), 120 and 105^{mm} high, with large leaves.

Pot 16. One shoot (from a cut potato), 190^{mm} high, with large leaves.

In darkness

Pot 17. One shoot (from a cut potato), 130^{mm} high, with large leaves.

Pot 18. Two shoots (from a cut potato), 105 and 150^{mm} high, with large leaves.

Although the plants were kept under these conditions for ten days, no intumescences were formed. The leaves on the plants in the dark became yellow and the plants finally died.

EXPERIMENT VI

Four pots of plants were placed in a shaded portion of the greenhouse over warm water pipes, where their roots would be kept warm.

Pot 19. Two shoots (from a whole potato), 177 and 187^{mm} high, with large leaves.

Pot 20. Two shoots (from a whole potato), 150 and 170^{mm} high, with large leaves.

Pot 21. One shoot (from a cut potato), 85^{mm} high, with rather small leaves.

Pot 22. One shoot (from a cut potato), 105^{mm} high, with rather small leaves.

Results

In four days the leaves of nos. 19 and 20 were nearly covered with intumescences. Pots 21 and 22 also produced them, but they were not as numerous as on the preceding, and the growth of the plants was more rapid.

From this set of experiments it appears that intumescences appear in light and in the shade when the plants are abundantly supplied with water and their transpiration is reduced. They are found still more abundantly when their roots are kept warmer. Intumescences are not formed in complete darkness nor in light or darkness when the absorption of the roots is lessened by cold. Intumescences were not produced in any case on plants which were not covered by the bell jars.

At the end of this series of experiments all the plants used, as well as those grown outside the bell jars, were cut down and allowed to grow up again. Healthy shoots came up from all the plants excepting those which had been kept in darkness and had been killed by the rotting of their leaves and stems. In about ten days a few of the plants had reached a sufficient height to cover with the bell jars and the preceding experiments were repeated.

EXPERIMENT VII

Plants placed in sunlight and covered May 7.

Pot 23. Two shoots (from a cut potato), 140 and 120^{mm} high, with large leaves

Pot 24. Three shoots (from a whole potato), 150, 170, 180^{mm} high, with large leaves.

In five days both plants showed many intumescences scattered over the leaves. No. 23 was particularly badly affected. There was a cold spell May 7–12, with temperature ranging from 62°–68° F., and a cloudy sky most of the time. On May 12 it became bright and warm, with a temperature of 72° F. Intumescences were then formed in great numbers.

EXPERIMENT VIII

Two plants were placed in darkness at the same time, with the other conditions similar to those of the preceding experiment.

Pot 25. Two shoots (from a cut potato), 180^{mm} with large leaves, and 70^{mm} with small leaves.

Pot 26. Three shoots (from a whole potato), 240, 170, 170^{mm}, with large leaves.

In five days no intumescences were formed and the leaves became yellow and decayed.

EXPERIMENT IX

Two plants were placed under whitewashed glass, with their roots kept warm.

Pot 27. Two shoots (from a cut potato), 150 and 150^{mm} high, with large leaves.

Pot 28. Two shoots (from a cut potato), 200 and 220^{mm} high, with large leaves.

These were covered with bell jars on May 12, a bright warm day with temperature 72° F. In two days intumescences had formed very numerously on both plants. Plant no. 27, as shown in the photograph (*fig. 1*), was very heavily covered with intumescences, both on leaves and stem.

EXPERIMENT X

Two plants were placed in the dark, with their roots kept warm.

Pot 29. Two shoots (from a whole potato), 170 and 220^{mm} high, with large leaves.

Pot 30. Two shoots (from a cut potato), 160 and 200^{mm} high, with large leaves.

No intumescences were formed from May 12 to 15, but the leaves became yellow and decayed.

EXPERIMENT XI

Two plants were kept with their roots cold by packing the pots in ice.

Pot 31. In light; two shoots (from a whole potato), 200 and 190^{mm} high, with large leaves.

Pot 32. In darkness; three shoots (from a whole potato), 150, 150, 150^{mm} high, with large leaves.

These plants were left under these conditions from May 15 to 24, and no intumescences were formed. The temperature of the air in the bell jars was about 73° F., and of the soil 55° F.

EXPERIMENT XII

Four plants were placed in the shade, with their roots kept cold. The temperature of the roots averaged 56° F., and of the air above 73° F.

Pot 33. One shoot (from a cut potato), 135^{mm} high, with rather large leaves.

Pot 34. One shoot (from a cut potato), 100^{mm} high, with large leaves.

Pot 35. Three shoots (from a whole potato), 135, 100, 115^{mm} high, with large leaves.

Pot 36. Two shoots (from a cut potato), 210 and 160^{mm} high, with large leaves.

These plants were allowed to remain eleven days under these conditions and no intumescences were formed. Some of the leaves became yellow.

EXPERIMENT XIII

Four plants were placed in the shade, with their roots kept warm from the warm water pipes. The temperature of the air in the bell jars averaged about 84° F.

Pot 37. One shoot (from a whole potato), 170^{mm} high, with large leaves.

Pot 38. Two shoots (from a cut potato), 120 and 100^{mm} high, with large leaves.

Pot 39. Two shoots (from a cut potato), both 130^{mm} high, with large leaves.

Pot 40. Three shoots (from a cut potato), 175, 150, 100^{mm} high, with large leaves.

In four to five days intumescences had formed in very great numbers over all four of these plants.

On May 25, shoots which had come up a third time from the same lot of potatoes were covered with bell jars.

EXPERIMENT XIV

Two pots were placed in sunlight.

Pot 41. One shoot, 150^{mm} high, with large leaves.

Pot 42. One shoot, 200^{mm} high, with a slender stalk and small leaves.

In seven days no intumescences were formed.

EXPERIMENT XV

Two pots were placed in the dark.

Pot 43. Two shoots, 200 and 230^{mm} high, with large leaves.
Pot 44. Two shoots, 300 and 300^{mm} high, with small leaves.
In seven days no intumescences were formed.

EXPERIMENT XVI

Two plants were placed in the shade.

Pot 45. Three shoots, 200, 180, 160^{mm} high, with small leaves.
Pot 46. Two shoots, 200 and 220^{mm} high, with small leaves and a slender stalk.
In seven days no intumescences were formed.

EXPERIMENT XVII

Two plants were placed under whitewashed glass and their roots kept warm.

Pot 47. Two shoots, 240 and 100^{mm} high, with small leaves, but having flower buds.
Pot 48. Three shoots, 60, 150, and 200^{mm} high, with small stalks and leaves.
In seven days no intumescences had formed.

That the intumescences did not form at all in this last series of experiments affords a suggestion as to their cause in the first set of young plants. The high osmotic pressure in the cells of the leaf is very probably brought about by the glucose in the leaves, which is furnished in great abundance to the young growing parts from the starch in the tuber, and is also assimilated in light by the leaves. In the case of these last experiments, the shoots which had been sent up the third time from the same tubers would thus be poorly supplied with glucose and the osmotic tension in the cells would not be so great. SORAUER (**20**), in a recent paper on the formation of internal intumescences on *Cereus nycticalis*, found a great abundance of glucose in the affected tissue and considered this to be the osmotically active substance which produced abnormal enlargement of the cells when a great amount of moisture was supplied. In the tomato ATKINSON (**1**) suggested that this substance is some organic acid, the production of which is increased by the low temperature and lessened light conditions under which the oedema developed. It is therefore very probable that the intumescences in the young potato

shoots are due to the presence of glucose when the other conditions of a humid atmosphere and an abundance of water for absorption are present.

As before stated, intumescences were not formed in complete darkness, but were developed in very great numbers in the shade and in the light, when supplied with an abundance of water and the root conditions were favorable for absorption. They were not formed on the young growing tips or on the old leaves which had ceased to grow. The explanation would therefore seem to be connected with the phenomenon of growth. It is probable that they did not form in total darkness because here the plants were stimulated to a rapid elongation of the cells in the stem and could thus take care of the abundant water supplied. At the same time, the glucose would not be so abundant as in plants growing in the light, since no assimilation takes place in darkness. For the same reason they did not form on the growing tips of the plants. They were formed in the sunlight and in the shade because elongation of the cells is not so rapid as in the dark and carbon assimilation is active. The plants could not thus take care of the water supplied fast enough, and the abundance of glucose in the growing leaves brought about the abnormal turgescence which caused the intumescences. That the intumescences were not found on the old mature leaves was probably due to the fact that these leaves had stopped growing and the cell walls were firmer, while less glucose was supplied to the cells from the tubers. When the tubers were healthy, intumescences formed equally well on plants from whole and cut potatoes. It would seem, therefore, that bright light is not necessary to the formation of intumescences in the case of the potato plant, nor does it act as a stimulus to their formation. This stimulus comes from the increased absorption of water and lessened transpiration with an abundance of glucose, and when enough light is present to produce the conditions for normal growth and assimilative activity.

To obtain a more accurate knowledge of the light intensity, in the various places in the greenhouse where the plants were placed, Wynn's photographic exposure meter was used. This instrument is manufactured for the use of photographers in measuring light intensity. The light values are obtained by exposing sensitized paper for a

time sufficient to bring it to the shade of a painted standard. The time which is necessary to produce the given shade may then be compared with the time taken to make the standard, which in this case was two to three seconds in bright sunlight at noon. In these experiments four seconds were necessary to produce the standard shade directly under the glass in sunlight, fifteen seconds under the whitewashed glass, and forty seconds in the shade. If the light value of the standard is represented by 1, the proportional light values under the three conditions given would be as follows:

Sunlight	Shade	Whitewashed glass
1.33	13.33	5.00

This method of obtaining light values is described by CLEMENTS (**2**, pp. 49–64). In order to test the power of new shoots from fresh potatoes to form intumescences, a new set of thirty-six potatoes was planted June 5; and June 25 the shoots were covered by the bell jars.

EXPERIMENT XVIII

In sunlight with an average temperature of 79° F.

Pot 48. Three shoots (from a whole potato), 240, 150, 150^{mm} high, with large leaves.

Pot 49. Four shoots (from a cut potato), 320, 340, 300, 280^{mm} high, with large leaves.

Pot 50. Three shoots (from a whole potato), with large leaves, 280, 230, 230^{mm} high.

Pot 51. Two shoots (from a whole potato), 200 and 240^{mm} high, with large leaves.

Pot 52. Four shoots (from a whole potato), 200, 240, 200, 220^{mm} high, with large leaves.

After two days intumescences had begun to form, and in three days they had formed on all the plants excepting no. 52. Although this was left covered for a few days longer, intumescences did not form.

EXPERIMENT XIX

Five plants were placed in the shade, with an average temperature of 73° F.

Pot 53. Four shoots (from a cut potato), 240, 280, 210, 260^{mm} high, with large leaves.

Pot 54. Three shoots (from a whole potato), 260, 230, 270^{mm} high, with large leaves.

Pot 55. Three shoots (from a whole potato), 120, 130, 150^{mm} high, with large leaves.

Pot 56. Four shoots (from a whole potato), 250, 240, 220, 100^{mm} high, with large leaves.

Pot 57. Four shoots (from a whole potato), 130, 160, 170, 190^{mm} high, with large leaves.

In two days intumescences had begun to form on all the plants. In three days they were very numerous over all the plants.

EXPERIMENT XX

Five plants were placed in darkness, with an average temperature of 79° F.

Pot 58. Four shoots (from a cut potato), 300, 250, 250, 270^{mm} high, with large leaves.

Pot 59. Three shoots (from a cut potato), 280, 300, 290^{mm} high, with large leaves.

Pot 60. Three shoots (from a whole potato), 300, 250, 140^{mm} high, with large leaves.

Pot 61. Three shoots (from a cut potato), 230, 130, 150^{mm} high, with large leaves.

Pot 62. Three shoots (from a cut potato), 240, 220, 200^{mm} high, with large leaves.

In five days none of the plants had developed intumescences, but they were very badly decayed from the excessive warmth and moisture.

EXPERIMENT XXI

At the same time some of the old plants, the second and third shoots from potatoes planted previously, were placed under bell jars. They all had rather small leaves and slender stems and were from 200 to 300^{mm} high. Three were placed in the shade and three in the sunlight and all failed to produce intumescences.

EXPERIMENT XXII

A few shoots of potatoes were stimulated with the various copper salts used by VON SCHRENK (**9**) in producing this disease on the cauliflower, to see if they would have a like effect upon the potato plant. The leaves of two shoots were stimulated with the following salts: copper ammonium carbonate, copper sulfate, copper acetate, copper nitrate, copper chlorid.

At the same time two shoots of the old plants were stimulated with each of these salts. All of these plants were left uncovered. After twenty-four hours burnt patches appeared on all the shoots wherever the sprays struck. The entire tissue through the leaf to

the under side in these patches was killed. No intumescences were formed on the old plants. On the new plants in two days a few intumescences formed as follows. On the first shoot sprayed with copper nitrate a few intumescences were produced over the veins. On the second shoot a few were formed on the surface. On one shoot sprayed with copper ammonium carbonate a few intumescences appeared at the tip of a leaf. The potato plants which were used, however, were not very healthy ones and developed from poor, shriveled, small tubers. These shoots would not form intumescences under bell jars when supplied with water, which fact was probably due to the leaves being poorly supplied with glucose. Had healthy young plants been used, it is very possible that intumescences would have been readily produced.

SUMMARY

Intumescences are produced on young potato plants from good tubers, when transpiration is checked and the roots are absorbing water. Their formation is increased by conditions which favor an increased absorption of water, as a warm soil, and is prevented by the opposite condition of a cold soil.

Intumescences are formed abundantly both in bright light and in weak light, which shows that light acts as a stimulus to their production only so far as it provides for the normal metabolism of the shoots and leaves.

Intumescences are not produced in total darkness, as this condition favors the rapid elongation of cells in the stem, which can thus make use of an increased supply of water. At the same time there is less of the osmotically active substance present in the leaves in darkness as photosynthesis is not taking place.

The abnormal state of turgescence of the hypertrophied cells is probably due to the osmotic action of glucose, assimilated in part by the leaf, but principally supplied to it from the underground tuber, so richly provided with starch.

In conclusion, I wish to acknowledge the many helpful suggestions of Professor ATKINSON, under whose direction this work was undertaken.

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LITERATURE CITED

1. ATKINSON, GEO. F., Oedema of the tomato. Bull. Cornell Univ. Agr. Exp. Sta., No. 53. 77–108. *pls. 1–8.* 1893.
2. CLEMENTS, F. E., Research methods in ecology. The University Publishing Co., Lincoln, Neb. 1905.
3. DALE, MISS E., Intumescences on *Hibiscus vitifolius* (L.). Annals of Botany **13**:622–624. 1899.
4. ———, Investigations on the abnormal outgrowths, or intumescences on *Hibiscus vitifolius*. Phil. Trans. Roy. Soc. London B. **194**:163–182. *figs. 1–2.* 1901.
5. KÜSTER, ERNST, Ueber experimentell erzeugte Intumeszenzen. Ber. Deutsch. Bot. Gesells. **21**:452–458. 1903.
6. ———, Pathologische Pflanzenanatomie 83–90. *figs. 20–23.* Jena. 1903.
7. NOACK, F., Eine Treibhauskrankheit der Weinreibe. Gartenflora **50**:619–622. 1901.
8. PRILLIEUX, ED., Intumescences sur les feuilles d'oeillets malades. Bull. Soc. Bot. France **39**:370–373. 1892.
9. SCHRENK, H. VON, Intumescences formed as a result of chemical stimulation. Ann. Rept. Mo. Bot. Gard. **16**:125–148. *pls. 25–31.* 1905.
10. SORAUER, P., Handbuch der Pflanzenkrankheiten. **1**:222–227. *figs. 3–4.* 1886.
11. ———, Ueber Gelbfleckigkeit. Forsch. Geb. Agr. Physik **9**:387–398. 1886.
12. ———, Mitteilungen aus dem Gebiete der Phytopathologie. 2. Die symptomische Bedeutung der Intumescenzen. Bot. Zeit. **48**:241–251. 1890.
13. ———, Weitere Beobachtungen über Gelbfleckigkeit. Forsch. Geb. Agr. Physik **13**:90–113. 1890.
14. ———, Ueber die Knotensucht des Gummibaumes. Prak. Rat Obst. Gartenbau, No. 4, pp. 48–50. *figs. 1–2.* 1890.
15. ———, Einige Beobachtungen bei der Anwendung von Kupfermitteln gegen die Kartoffelkrankheit. Zeit. Pflanzenkrank. **3**:32–36. 1893.
16. ———, Intumescenzen bei *Solanum floribundum*. Zeits. Pflanzenkrank. **7**: 122–123. 1897.
17. ———, In Deutschland beobachtete Krankheitsfalle. (Intumescenz an Blättern der Nelken.) Zeits. Pflanzenkrank. **8**:291. 1898.
18. ———, Ueber Intumescenzen. Ber. Deutsch. Bot. Gesells. **17**:456–460. *fig. 1.* 1899.
19. ———, Intumescenzen an Bluten. Ber. Deutsch. Bot. Gesells. **19**:115–118. *fig. 1.* 1900.
20. ———, Erkrankung von *Cereus nycticalis*. Zeits. Pflanzenkrank. **16**:5–10. *pls. 1–2.* 1906.
21. VIALA, P. and P. PACOTTET, Sur les verrues des feuilles de la vigne. Compt. Rend. Acad. Sci. **138**:161–163. 1904.

GRAVITY AS A FORM-STIMULUS IN FUNGI

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY XCII

HEINRICH HASSELBRING

(WITH THREE FIGURES)

The directive influence of gravity in determining the position of the hymenium in the higher Basidiomycetes is a matter of common observation. The fruit-bodies of these fungi are universally oriented so that the hymenium is exposed toward the earth's surface. If the normal position of the fruit-body is changed, either by accident or by experimentation, readjustment takes place by which the hymenial surface is again brought into a horizontal plane, provided of course that such readjustment is not hindered by other factors. Interesting cases illustrating these phenomena are given by ATKINSON[1] and also by WATERS.[2]

The methods by which the horizontal orientation of the pileus is brought about are two. First, in all stalked forms, such as the Agaricaceae, and some of the Polyporaceae and Hydnaceae, the stalks are negatively geotropic, and by their curvature always bring the pileus into a horizontal position. This property was first observed by HOFMEISTER[3] in some of the Agaricaceae. The phenomena may be observed in all stalked forms growing on the sides of trees or stumps. Here the stems curve upward until the pileus is brought into the normal position. Second, in forms which have no stalk, and this applies especially to sessile forms of Polyporaceae, the orientation of the hymenium is brought about by the growth of the trama-plates themselves, for, as SACHS[4] has shown, the trama-plates of the hymeno-

[1] ATKINSON, G. F., Mushrooms, edible, poisonous, etc. pp. 13–17. 1900.

———, Some wood-destroying Fungi. Geol. Surv. of Louisiana, Rep. **1899**: 333–338. *pls.* 7.

[2] WATERS, C. E., Geotropism of Polyporus. Plant World **7**:224. 1904.

[3] HOFMEISTER, W., Ueber die durch die Schwerkraft bestimmten Richtungen von Pflanzentheilen. Jahrb. Wiss. Bot. **3**:92. 1863.

[4] SACHS J., Experimental Physiologie. p. 93. 1865.

phore, not only in the Polyporaceae but also in the Hydnaceae and Agaricaceae, are positively geotropic. Since in non-stalked forms adjustment of the whole pileus is obviously impossible, the downward growth of the hymenophore alone is responsible for the orientation of the hymenium. If the position of the growing pileus is changed, readjustment to the new condition is accomplished solely by the change in direction of growth of the elements of the trama-plates and the growing, undifferentiated elements of the pileus. This often results in the formation of new pilei growing at various angles from the old pileus (see ATKINSON, *l. c.*).

In such types as the Polyporaceae it is evident that the form of the fungus depends to a large extent on the growth of the trama-plates making up the hymenophore. Since the mode of growth of these elements is greatly influenced by gravity, the question naturally arises as to what extent the form which these fungi assume is determined by the responses of the elements to the influence of gravity. To determine the effect of gravity as a form-stimulus, klinostat experiments were conducted with a number of fungi from different families. As a rule sticks and branches upon which sporophores were growing were brought into the laboratory for experimentation. Although a considerable number of plants were thus tried, only a few gave results, owing, no doubt, to the fact that the conditions of growth of these forms are not sufficiently well understood so that they can be cultivated with certainty. From a few forms interesting results were nevertheless obtained. The experiments are here first described, and this is followed by a discussion of the significance of the results obtained.

In October 1905 a small fruit-body of *Polystictus cinnabarinus* growing on a stick was placed in a moist chamber and rotated on the horizontal axis of the klinostat until the middle of December. The fruit-body was a little over 1^{cm} in diameter, with few pores, and growing at the margin. During the experiment its growth was slow, although the plant appeared to remain healthy. At the end of the experiment the plant was about 2^{cm} in diameter. The new growth, however, was not confined to the margin as in stationary fruit-bodies, but owing, no doubt, to the still embryonic condition of the fruit-body growth was resumed over the entire surface, resulting

in a pulvinate fruit-body. The most remarkable result of the experiment, however, is this: the fruit-body was no longer differentiated into a sterile dorsal and fertile ventral surface; the whole pulvinate body was covered with tubes characteristic of the hymenial surface of this fungus. At the present time it is scarcely possible to distinguish the original dorsal and ventral surfaces of the specimen, which has been preserved in alcohol. With the suspension of the differentiation of dorsal and ventral surfaces, all tendency of the fruit-body to produce the normal shelf-like form is of course lost.

On October 9, 1906, a stick with several growing fruit-bodies of *P. cinnabarinus* was placed in a moist chamber as before, and revolved in a dark chamber until December 15. At the same time several other sticks with growing fruit-bodies were similarly arranged and revolved, without excluding the light. Of all the fruit-bodies used in this experiment only one rather large specimen in the dark chamber showed any uniform growth.[5] This one had grown on the upper side of a dead branch, so that it had a somewhat rotate form, attached at the center. The sporophore was about 3.5^{cm} in diameter. The growth of this plant on the klinostat was extremely slow, so that it did not enlarge much. New growth occured along a zone on the margin, extending back for about 1^{cm} over the dorsal surface. The result was a tumid thickening of the otherwise somewhat acute margin of the pileus. Here again the whole growing zone showed the incepts of numerous pores characteristic of the hymenial surface. That these were not more developed, as in the former case, is due to the unfavorable conditions of growth, for it should be remembered that the other fruit-bodies used in this experiment, whether growing in light or darkness, made scarcely any growth at all, although they remained fresh and normal to all appearances.

Among the Agaricaceae experiments were carried out with *Schizophyllum commune* and some species of Coprinus.

Pieces of a maple branch containing mycelium of Schizophyllum were placed on the klinostat as in former experiments. At the beginning of the experiment any traces of sporophores visible on the

[5] At the end of the experiment it was found that several of the smaller fruit-bodies had developed well-marked pores in patches, where growth had been resumed on the margin and on the upper surface.

branch were removed. It was therefore certain that if any fruit-bodies appeared, they had developed from their earliest stages on the klinostat. The precaution is important, since the fruit-bodies of the Agaricaceae are completely differentiated during their earliest stages of growth. Beyond these stages the parts, therefore, can no longer be subject to formative stimuli. On several of these sticks the fruit-bodies developed within about a month. They appear as small outgrowths resembling simple forms of Clavaria, and attain a length of about 1^{cm}. Early in their development a cup-like depression appears at the summit, and within this the rudimentary lamellae are formed, radiating from the center. The fruit-bodies at this stage have the form of a short trumpet about 1^{cm} long. The outside has the characteristic appearance of the dorsal surface of the normal fruit-body. By subsequent growth the margin expands uniformly at first, but later unequally, so that the resulting fruit-body is a lobed disk, $2–3^{cm}$ in diameter, and stalked at the back. The curious fact brought out by this experiment is that the lamellae develop on the inner side of the trumpet- or funnel-shaped fruit-body. The pileus, therefore, appears to be attached at the back, with the lamellae developing on the morphologically upper side.

To study the effect of gravity on some more specialized form, dung-cultures were set up for Coprinus. These were continually rotated so that the entire development of the fungi from the germination of the spore to the maturation of the fruit-body took place on the klinostat. The primordia of the fruit-bodies were thus at no time subject to the normal influence of gravity. Several crops of Coprinus developed on the cultures, but the fruit-bodies were normal in every way. Their direction of growth was perpendicular to the substratum, the actual direction being horizontal, since the pots were rotated on the horizontal axis of the klinostat.

The experiments with the foregoing three types show the existence of a marked difference in the degree to which the form of these types is modified by or depends upon the stimulus of gravity. Of the plants studied, Polystictus is the more plastic, and is consequently more influenced by gravity. Here the differentiation of the fruit-body into the sterile dorsal and fertile ventral surface depends on the direct or indirect action of gravity. In Schizophyllum the tissue

differentiation is independent of the external stimulus of gravity, but the general form of the plant is somewhat modified in a way to be considered later. In the highly differentiated Coprinus the morphogenic influence of gravity is not evident.

The sporophores of all the higher fungi are made up of a complex mass of hyphae whose growth is so correlated that the final result is the definitely organized fruit-body. These hyphae must be considered to a large extent as independent individuals, for they have organic connection only in so far as they arise from common branches many cell generations back in the tissue, or in so far as they are united by subsequent fusion which is comparatively rare. The elements, nevertheless, grow in unison to form the sporophore. As the organization of the sporophore is in the main the result of successive changes in the direction of growth of elements,[6] it seemed possible that this mode of growth might be determined by external stimuli, coupled of course with a changing capacity of the elements for reacting to those stimuli. For example, if gravity alone were considered, the hyphae organizing the pileus of mushrooms might be plagiotropic while forming the cap, those on the lower side becoming positively geotropic to organize the lamellae, while the hyphae organizing the hymenium would again be plagiotropic. Of course it is not supposed, and the experiments bear this out, that any case would yield to so simple an analysis as this, for it is still possible that the plant has within itself an inherited tendency toward a definite organization, and even if this is not admitted the common chemotropic and thigmotropic actions of the hyphae upon each other play an important part. That direct external stimuli also play an important part is shown by the non-development of *Lentinus lepideus*[7] in the dark. The caps of some species of Coprinus[8] also are dependent upon light

[6] ATKINSON, G. F., The development of *Agaricus campestris*. BOT. GAZETTE **42**:241–264. *pls. 6.* 1906; the older literature is reviewed here.

ALLEN, C. L., The development of some species of Hypholoma. Ann. Myc. **4**: 387–394. *pls. 3.* 1906.

[7] REINKE, J., Ueber Deformation von Pflanzen durch äussere Einflüsse. Bot. Zeit. **62**:81–112. *pl. 1.* 1904; see the literature given here.

BULLER, A. H. R., The reactions of the fruit-bodies of *Lentinus lepideus* Fr. to external stimuli. Annals of Botany **19**:427–438. *pl. 4.* 1905.

[8] BREFELD, O., Untersuchungen über Schimmelpilze **3**:87–97, 114–115. 1877.

for their development. In these cases the development of the pileus is retarded or suppressed, so that it is probable that here light acts as something more than a tropic stimulus. BULLER (*l. c.*) has recently shown, however, that the lamellae of Lentinus develop first and most vigorously on the lower side of the young fruit-body when it arises obliquely from the substratum, and that this unilateral development is due to the effect of gravity. Here we have a change in form due to the effect of gravity. It is probable that the eccentricity of the stalks of tree- and stump-inhabiting forms is directly due to such action of gravity, for when some of these forms, like *Pleurotus ulmarius*, develop on the upper side of a fallen trunk they are symmetrical.

In *Polystictus cinnabarinus*, as in other shelf-forms, the fruit-bodies increase in size by growth at the margin. The hyphae near the lower side of the growing margin turn downward and produce the hymenophore. The epinastic growth (if this term, originally applied only to dorsiventral organs, may be employed) of these hyphae is due to their positive geotropism, for on the klinostat they grow uniformly in all directions. The organization of the hymenophore itself is not dependent upon gravity, for when this force is equalized all the hyphae form hymenial tissue. The differentiation of the fruit-body into an upper sterile and a lower fertile region is also due ultimately to the influence of gravity. All the hyphae are potentially fertile, but the development of a hymenium by the upper hyphae is inhibited finally by gravity. How this sterilization is brought about is another question. It is probable that the direct cause is to be sought in the mechanical or chemotropic influences of the hyphae upon each other. Since experiments were conducted both in light and in dark, it is evident that light is not a factor in this case.

The form of the more highly organized Schizophyllum is influenced in a less degree. It is evident that the general organization of the fungus is quite independent of the stimulus of gravity. There is one interesting phase, however, that needs to be considered. The fruit-bodies of this fungus are typically dorsiventral and laterally attached, yet on the klinostat they originate as small funnel-shaped bodies with the lamellae on the inside of the funnel; and when allowed to develop fully, the funnel expands and develops into a lobed disk,

stalked at the back and bearing the gills on the upper surface (*figs. 1* and *2*). It will be seen that the gills are not, as in all other Agaricaceae, on that surface of the pileus which is continuous with the stipe, *i. e.*, the lower surface, but on the opposite side, which corresponds to the dorsal surface of other mushrooms. In this respect Schizophyllum stands alone, at present, among the Agaricaceae. The growth of the fungus on the klinostat enables us to interpret the structure of the normal dorsiventral fruit-body.

Schizophyllum commune. FIG. 1.—Stalked symmetrical fruit-body grown on the klinostat. FIG. 2.—Lateral view. FIG. 3.—Fruit-body developed on lower side of branch lying on the ground, showing symmetrical structure. × 1.

The youngest primordia arise in the form of minute cups. If these are allowed to develop on the klinostat, the tendency of the pileus to develop equally on all portions shows itself. If, however, the fungus grows out more or less horizontally from the substratum, as it normally grows, the lower half of the pileus ceases to develop, while the upper half grows into a fan-shaped fruit-body. The pileus may be regarded as a funnel with the gills on the inside, having its lower half cut away and the upper half flattened out so as to expose the gills in their normal position toward the earth. The inhibition of growth of the lower half is ultimately due to gravity, since on the klinostat all portions develop equally. The same effect is produced when the fruit-bodies grow on the lower side of sticks, as they often do in nature. Such specimens expand symmetrically on the margin, producing a rotate fruit-body attached at the back

and with the lamellae radiating in all directions from the center (*fig. 3*).

In the highly differentiated Coprinus no formative influence of gravity could be observed. It is evident that here the organization of the fruit-body depends largely upon internal causes or upon stimuli not yet sufficiently analyzed.

In conclusion, it follows from the foregoing observations, on three widely separated forms of the Basidiomycetes, that although gravity has no apparent effect on the organization of the hymenophore,[9] it has a marked influence on determining the configuration of the fruit-body of some forms. This effect is most marked in the more primitive forms, which are thereby shown to be the more plastic. In the more highly differentiated forms this effect of gravity disappears. The effect of gravity on the configuration of Polystictus is due partly to the positive geotropic property of the hymenophore, and partly to the fact that the differentiation of the fruit-body into sterile and fertile tissue depends on the action of gravity. When this force is removed, the fruit-body assumes the resupinate or a pulvinate form characteristic of the simplest types of the Basidiomycetes.

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[9] This term applies only to the parts immediately bearing the hymenium, *i. e.*, the gills, spines, etc., and not, as it is sometimes used, to the whole fruit-body.

ASCOGENOUS FORMS OF GLOEOSPORIUM AND COLLETOTRICHUM

C. L. SHEAR AND ANNA K. WOOD

An accurate knowledge of the life-histories of fungi is of the greatest importance, not only to taxonomy, but especially to plant pathology. As many parasitic fungi possess two or more fruiting stages, in some cases occurring on different hosts, it is necessary to have a full knowledge of their complete course of development in order to know how they are reproduced and distributed, and to devise adequate methods of combating or preventing them.

The fungi producing the diseases known as anthracnoses, which attack a great variety of wild and cultivated plants, have been described chiefly as species of Gloeosporium and Colletotrichum. The positive connection of these conidial forms with ascogenous stages was, so far as we are aware, first demonstrated by means of pure cultures by Professor G. F. ATKINSON, as reported by Miss STONEMAN[1] in 1898. FÜCKEL[2] in 1869 gave *Gloeosporium juglandis* Lib. (*Marsonia juglandis* (Lib.) Sacc.) as the spermagonial form of *Gnomonia leptostyla* (Fr.) Ces. & De Not., which occurs on *Juglans regia*. It has uniseptate conidia, and the ascospores are also uniseptate, which facts seem to indicate that it is not congeneric with the organisms with which we are concerned at present. FÜCKEL's statement in regard to the connection between these two forms was based simply upon the association of the two on the same leaf, and was merely a guess. KLEBAHN[3], however, has recently demonstrated by pure cultures and infection experiments that FÜCKEL was correct in this case. Other forms studied by KLEBAHN, which have passed under the name of Gloeosporium, are *G. nervisequum* (Fück.)

[1] STONEMAN, B., The development of some anthracnoses. BOT. GAZETTE **26**: 69. 1898.

[2] FÜCKEL, L., Symbolae Mycologicae 123. 1869.

[3] KLEBAHN, H., Zuzammenhänge von Ascomyceten mit Fungis imperfectis. Cent. f. Bakt. **15²**:336. 1905.

Sacc.[4] and *G. Ribis* (Lib.) Mon. & Desm.[5] The first of these he connects with *Gnomonia veneta* (Sacc. & Speg.) Kleb., which has uniseptate ascospores, and hence is not congeneric with the anthracnoses, whose ascospores are not septate. In the case of *G. Ribis*, KLEBAHN[5] claims to have demonstrated by infection experiments and by pure cultures that its ascogenous stage is a discomycete, which he has described as *Pseudopeziza Ribis*. It is very remarkable if conidial forms so similar as to be placed by taxonomists in the same genus should have ascogenous stages belonging to such different, distinct groups as the Pyrenomycetes and the Discomycetes. Miss STONEMAN (*l.c.*) in 1898, CLINTON[6] in 1902, VON SCHRENK and SPAULDING[7] in 1903, SHELDON[8] in 1905 and 1906, and SCOTT[9] in 1906 have worked with organisms from various hosts which have usually passed under the name of Gloeosporium or Colletotrichum, and which are undoubtedly congeneric with the plants treated of in this paper.

We may say, in the beginning, that neither of the names just mentioned is tenable for any of the plants to be considered here, as these names were originally applied to species belonging to other genera than those to which they are applied by SACCARDO and other recent mycologists. The name Glomerella, of SPAULDING and VON SCHRENK, will be used here, as it is the only one which we are absolutely certain at present belongs to this group of organisms. There is little doubt, however, that there are older valid generic names which have been applied to either the conidial or ascogenous stages of these

[4] KLEBAHN, H., Untersuchungen über einige Fungi imperfecti und die zugehörigen Ascomycetenformen. II. Jahrb. Wiss. Bot. **41**:515. 1905.

[5] ———, Untersuchungen über einige Fungi imperfecti und die zugehörigen Ascomycetenformen. III. Zeits. Pflanzenkrank. **16**:65. 1906.

[6] CLINTON, G. P., Apple rots in Illinois. Agr. Exp. Sta. Bull. no. 69. 1902.

[7] SCHRENK, H. VON, and SPAULDING, P., The bitter-rot of the apple. U. S. Dept. Agr., Bur. Pl. Ind., Bull. no. 44. 1903.

[8] SHELDON, J. L., Concerning the identity of the fungi causing an anthracnose of the sweet-pea and the bitter-rot of the apple. Science N. S. **22**:51. 1905.

———, The ascigerous stage of *Gloeosporium Psidii*. Science N. S. **21**: 143. 1905.

———, The ripe rot or mummy disease of guavas. W. Va. Agr. Ex. Sta. Bull. no. 104. 1906.

[9] SCOTT, W. M., The control of the apple bitter-rot. U. S. Dept. Agr., Bur. Pl. Ind., Bull. no. 93. 1906.

fungi, but until we have had opportunity to study the types of the genera to which they may belong, we prefer to use the name Glomerella for at least all the species which are known to have ascogenous stages congeneric with *Glomerella rufomaculans* (Berk.) Spauld. & v. Schrenk.

The first published work on the life-history of these fungi was that of Miss STONEMAN, in 1898; she worked with twelve forms from as many different hosts, and succeeded in producing in pure cultures both the conidial and ascogenous stages in four cases, and a doubtful fifth, as follows:

Glomerella cingulata (Stoneman) Spauld. & v. Schrenk, the conidial stage occurring on privet (*Ligustrum vulgare*); *G. piperata* (Stoneman) Spauld. & v. Schrenk, the conidial stage found on pepper, *Capsicum* sp.; *G. cincta* (Stoneman) Spauld. & v. Schrenk, the conidial stage occurring on an orchid, *Maxillaria picta*, and provisionally referred to Colletotrichum; *G. rubicola* (Stoneman) Spauld. & v. Schrenk, the conidia from red raspberry, *Rubus strigosus;* *G.* (?) *Vanillae* (Stoneman) Spauld. & v. Schrenk, the conidia from the cultivated vanilla.

Miss STONEMAN referred all these species to a new genus, which she named *Gnomoniopsis*. This name was untenable, however, having been previously used by BERLESE[10] for another genus of fungi. CLINTON (*l. c.*) in 1902, seems to have been the first to obtain in pure cultures the ascogenous stage of the Gloeosporium causing anthracnose or bitter-rot of the apple. VON SCHRENK and SPAULDING (*l. c.*) in 1903, and SCOTT (*l. c.*) in 1906, also worked with the apple Gloeosporium and made additions to our knowledge of its life-history and conditions of development. SHELDON (*l. c.*) in 1906, reported the successful growth in pure cultures of the ascogenous stage of the guava anthracnose or ripe-rot, *Glomerella Psidii* (Del.) Sheldon. These six forms are the only ones whose life-histories have heretofore been determined by pure culture methods, so far as we have been able to learn from published records.

The present writers have studied a number of forms and have succeeded in growing both the conidial and ascogenous stages from eight different hosts, as follows:

Gloeosporium rufomaculans (Berk.) v. Thümen, from the cultivated grape, *Vitis* sp.; *G. fructigenum* Berk., from the apple; an apparently unnamed Gloe-

[10] BERLESE, A. N., Icones Fungorum 1:93. 1892.

osporium from the cranberry, *Vaccinium macrocarpum;* *G. elasticae* Cooke & Massee, from the leaves of the rubber plant, *Ficus elastica;* a form from the locust, *Gleditschia triacanthus*, which does not appear to have been reported before; one from *Ginkgo biloba*, also not heretofore reported; *Colletotrichum gossypii* Southw., from cotton; and *C. Lindemuthianum* (Sacc. & Magnus) Bri. & Cav., from the cultivated bean.

Of these eight only the one from the apple has had its ascogenous form reported heretofore. Miss STONEMAN worked with the anthracnose of the bean, but was unable to produce the ascogenous stage.

All the forms mentioned have been grown by the writers in pure cultures, and the ascogenous stages produced, in most cases, several times. The original cultures were usually obtained by the transfer to culture media of conidia or portions of the tissue of the host containing the hyphae of the fungus. We have been unable as yet to tell definitely what the factors are which control the production of the ascogenous form. Repeated experiments with various culture media, under various conditions of light, temperature, and moisture, seem to indicate that these are not factors of great importance. Once having obtained a race, strain, or generation which produces ascogenous perithecia in cultures, it can be successfully grown on various media and under various conditions for several generations.

The medium which we have found best adapted for use and which has produced the most abundant and luxuriant growths of ascogenous forms is sterilized corn meal. We have found by repeated experiments that if a culture from any particular acervulus or group of acervuli does not produce an ascogenous stage on corn meal at 75° to 85° F., it is useless to experiment further with material from the same source. Fresh material from other specimens must be tried until a race, strain, or generation is found which will produce its ascogenous form. It has been suggested that the nearness or remoteness of origin of the conidia from ascospores may be an important factor in determining the production of an ascogenous stage. The few experiments we have made along this line are not conclusive, and more data must be obtained before results can be reported.

Heretofore forms occurring on different hosts have been generally regarded as distinct species. The study which we have made of the eight forms just mentioned leads to the conclusion that they cannot

be successfully segregated as species upon the basis of morphological characters. Though we have examined a great deal of material, of both conidial and ascogenous stages, from various pure cultures, as well as from the natural hosts, we are unable to find any differences of sufficient constancy or importance to make it possible to distinguish species or even varieties except the host be considered. Miss STONEMAN describes and figures most of her species as having perithecia with a distinct neck or beak. We have very rarely seen in any of our cultures as conspicuous a beak as she figures. In all other characters, however, the forms we have studied agree with hers. The conidia of these fungi are well known to be quite variable in size and shape, and it is frequently possible to find in a single acervulus conidia varying in length from 10 to 25 μ and in thickness from 3.5 to 6 μ, so that the range of variation in a single culture will usually cover the range of variation found in any of the forms we have studied. This is not only true of the conidia, but is also true of the ascogenous forms. The greatest variation found in the size of ascospores is from 9 to 24 μ by 4.5 to 8 μ, the usual measurements being about 14 to 18 μ by 5 to 6 μ. In shape the asci vary somewhat, being usually sub-cylindrical or clavate. The ascospores vary but little in shape and appearance of contents. They are usually slightly curved or allantoid, having the contents in fresh specimens regularly granular, with a more or less distinct hyaline zone at the center, and when fully matured are of a light greenish-yellow color. This color, however, is hardly noticeable except in mature specimens. From this it will be seen that these organisms cannot be satisfactorily distinguished by their morphological characters, so far as the conidia and asci are concerned. Some of the conidial forms have been separated heretofore upon the basis of the presence or abscence of dark setae in the acervulus. This, as has been pointed out by other writers, is also an uncertain and variable character. We have found setae in the acervuli in one part of a pure culture, whereas in other parts of the same culture they were absent. We have also found this same variation in acervuli occurring upon leaves, especially in the form found upon the cranberry.

The question remains whether these organisms can or should be separated as physiological species. The answer depends upon

whether the forms are restricted to their individual hosts, or can be successfully transferred from one host to another. The work already done by HALSTED,[11] SOUTHWORTH,[12] and others in transferring various forms occurring upon different fruits from one host to another by inserting the conidia in the tissue of the host, or by applying them to the surface of mature fruits does not seem to us to be conclusive. A mature fruit, especially when the surface is ruptured, might be regarded simply as a culture medium, and the fact that these organisms will grow upon it does not prove that they would grow upon the plant as a parasite. The only conclusive test of this matter must be made by careful infection experiments, using fresh, living, and growing plants controlled by checks. SHELDON[13] reports having done this in the case of the anthracnose of the apple, having succeeded in infecting the leaves of the sweet-pea by transferring conidia from the apple. These experiments, in connection with others which have been reported to us verbally, seem to indicate that some of these forms are not physiologically distinct. In some cases at least the evidence indicates that plants which appear free from disease are already infected, the fungus apparently being in a dormant or more or less inactive condition and awaiting favorable conditions for development. In the anthracnose of cotton and bean, the disease is known to be transmitted by diseased seed. It is desirable, therefore, that plants used for infection experiments should be grown from healthy disinfected seed under such conditions as to prevent the possibility of infection from other sources. In the present state of our knowledge, perhaps it may be best to regard the various forms we have studied as varieties of one species.

The bodies frequently found in nature and in cultures, which have been called by some chlamydospores and by others appressoria, show no specific characters. While their function, perhaps, may be primarily that of appressoria or hold-fast organs, as maintained by HASSELBRING[14] and others, they are often produced under conditions

[11] HALSTED, B. D., Laboratory study of fruit decays. Report N. J. Agr. Exp. Sta. **1892**: 326. 1893.

[12] SOUTHWORTH, E. A., Ripe rot of grapes and apples. Jour. Myc. **6**:164. 1891.

[13] SHELDON, J. L., Concerning the identity of the fungi causing an anthracnose of the sweet-pea and the bitter-rot of the apple. Science N. S. **22**:51. 1905.

[14] HASSELBRING, H., Appressoria of the anthracnoses. BOT. GAZETTE **42**:135. 1906.

which seem to indicate that they may have some other function as well. They have frequently been found in our cultures, and occur also in cranberries that have been destroyed by the cranberry anthracnose. They vary considerably in size and shape, and the germ pore which is attributed to them is frequently indistinct or wanting.

Most writers who have studied the ascogenous stages of these fungi have described them as without paraphyses. SHELDON[15] has recently mentioned finding paraphyses in ascogenous perithecia produced from the apple. We have occasionally found organs surrounding the outer portion of the mass of asci which bear a close resemblance to the paraphyses of certain other pyrenomycetous fungi. A careful study of these organs shows that they are not intermingled with the asci, but are about the outer portion of the mass, next to the wall of the perithecium. In many instances they suggest aborted or malformed asci. In any case they would be more correctly called periphyses than paraphyses. Their rare occurrence would seem to indicate that they are of no great importance for taxonomic purposes.

Since these organisms have been found to produce ascogenous perithecia in cultures, it would be expected that they would also produce them under natural conditions upon their host plants. The conidial forms are so numerous and so widely distributed that if the ascogenous forms occur often they would probably have been found and described by mycologists before now. DELACROIX[16] describes *Glomerella* (?) *Artocarpi* as found on Artocarpus leaves associated with Gloeosporium and Colletotrichum. The description and figures agree well with our ascogenous forms. Since beginning this investigation we have examined carefully various plants attacked by anthracnose in the hope of finding ascogenous perithecia under natural conditions. Thus far, however, we have been able to find them in only two cases; that of the apple, which had already been reported by CLINTON (*l. c.*), and that of the rubber plant, *Ficus elastica*. The ascogenous perithecia are frequently found in abundance upon fallen leaves of the rubber plant, which have been attacked by the anthracnose, *Gloeosporium elasticae* Cke. & Mass. They agree in

[15] SHELDON, J. L., The ripe rot or mummy disease of guavas. W. Va., Agr. Exp. Sta., Bull. 104: 310. 1906.

[16] DELACROIX, G., Bull. Soc. Myc. France **21**:198. 1905.

every respect with those which are produced in pure cultures, except that the perithecia in the pure cultures are more or less overgrown with the vegetative hyphae, and this we find to be generally true in the case of cultures of perithecia of other fungi, which under natural conditions are borne within the tissues of the host. There are several genera of pyrenomycetous fungi which have characters so nearly like those of Glomerella that they cannot be very satisfactorily distinguished from it, and we are of the opinion that some of the species already referred to these genera are really the ascogenous stages of anthracnoses. Of such genera we may mention Physalospora, Phomatospora, and Guignardia. As already stated, for the present it seems advisable to treat these organisms as varieties of the oldest species, *Glomerella rufomaculans* (Berk.) Spauld. & v. Schrenk, which was originally described from specimens from the grape.

U. S. DEPARTMENT OF AGRICULTURE
Washington, D. C.

LICHEN DISTRIBUTION IN THE SANTA CRUZ PENINSULA, CALIFORNIA

ALBERT W. C. T. HERRE

The Santa Cruz peninsula, California, forms a rough triangle extending in a northwesterly direction from Monterey Bay on the south to the Golden Gate at the north, a distance of ninety miles or more. In breadth it varies from about thirty-five miles at the widest portion to perhaps six miles near the northern end. Laved on the west by the Pacific, its eastern boundary is formed by San Francisco Bay and the broad, originally treeless Santa Clara–San Benito valley; while at the southeast the Pajaro cuts its way through the range and separates it from the Gabilan range.

Rising from sea-level along most of its border, it reaches at its highest point an elevation of 3793 feet and embraces within its limits every variation between the dense, unbroken redwood forest and the bare, sea-girt rock, the cloud-swept mountain crag, and the vast expanse of monotonous salt marsh.

Separated thus from the adjacent country and having such a diversified surface, it forms a natural biological region, well known both to the zoologist and the botanist. Though lichens are notorious for their wide geographical distribution, a study of the Santa Cruz lichens shows that they too are affected by the comparative isolation of the peninsula.

In addition to its possession of a number of endemic forms, one of the most interesting features of the lichen flora of the Santa Cruz peninsula is the commingling of boreal or alpine, temperate, and tropical species. At the same time, there is a remarkable absence of certain lichens which we should naturally expect to find in the region. That no species of the genus Graphis should be found, and that *Cladonia rangiferina* and all forms of the genus Stereocaulon are absent, is an anomaly that as yet seems baffling, since forms ordinarily associated with all these are common.

But the mingling here of lichens typical of different phytogeographical regions can be explained, I believe, by a study of the

climatology of the Pacific Coast and of the Santa Cruz peninsula in particular, recognizing at the same time that the area under discussion is really an aggregate of a number of minor biological areas, each possessing distinct physiographic, faunal, and floral features, and marked by its own typical lichen species.

Most people, in a general way, have the idea that California has a subtropical climate, and that name is often applied to it. In reality, owing to its great area and wonderfuly diversified topography, California has many climates, but the typical Californian climate is, more than that of any other part of the United States, a true cool temperate climate; and it is to the rather cool but remarkably equable temperature conditions that we primarily owe the interesting intermixture of lichens typical of unlike life-regions.

As typical of the temperature of the Santa Cruz peninsula I quote the following averages for the twelve months of the year, as fixed by observations at San Francisco extending over more than half a century: "January, 52.2° F.; February, 52°; March, 54°; April, 55°; May, 57°; June, July, and August, each 59°; September, 60.8°; October, 60°; November, 56°; December, 52°."

These temperatures will favor the boreal or alpine forms such as *Gyrophora polyphylla*, *Evernia vulpina*, *Lecidea caeruleo-nigricans*, *Rhizocarpon geographicum*, and others of like character; while at the same time they will permit of the migration from warmer regions of various species of Ramalina, Dendrographa, Dirina, Lecanactis, Schismatomma, etc.

While the temperature conditions of the whole Santa Cruz peninsula are quite uniform, the annual rainfall shows great variation in different localities, ranging from 50 or 60 inches at Boulder Creek, and even more in the Big Basin, to 13 or 14 inches at Stanford University.

For detailed statistics on this whole matter, however, one must refer to Professor ALEXANDER MCADIE'S valuable work upon *The Climatology of California*.

A study of the lichen flora of the Santa Cruz peninsula shows that it is more or less sharply divided into a number of biologic areas, which may be roughly classified as the maritime, foothill, chaparral, mountain-forest, and mountain-peak areas.

The maritime area is sharply defined, more so in fact than any of the others, and includes not only a narrow strip of land all along the coast but also all of the northern tip of the peninsula down to and including the San Bruno mountains. Most of this area is of course of low elevation, but in the northern part of San Mateo County, where the broken hills of San Francisco culminate in San Bruno mountain, it extends to an altitude of more than 1300 feet.

This maritime region possesses the most equable climate of the peninsula, and also perhaps the highest daily average of humidity. It is characterized by relatively cold, windy, and foggy summers, the fogs mitigating the dryness of the rainless summer months; the winters are comparatively clear, sunshiny, with less precipitation than the redwood forests farther inland, and much warmer than in the other areas. At several points along the coast a whole winter often passes without the temperature once falling to 32° F.

This area may (in a large way) be considered as a part of the belt which extends southward to the tropics, and beginning again on the coast of Peru reaches far to the south of Valparaiso, Chile. It is a region in the main of slight rainfall and very moderate range of temperature, and it is therefore not surprising that we find a number of rock or earth lichens common alike to the shores of California, Peru, and Chile, yet unknown except on the Pacific coast of the Americas.

I have no means of knowing how far to the north of the Golden Gate these forms go, but most of them, including those originally described by TUCKERMAN from the San Francisco Bay region, seem to become more luxuriant as we go farther south, though I have seen none from below Guadalupe Island, Lower California. This would seem to indicate that such forms may be regarded as migrants from regions lying nearer to the tropics, and that the Golden Gate is very near to their northern limit, if indeed they go beyond it. In this category we may place most of the characteristic lichens of the maritime region.

The characteristic lichens of this area do not occur in any of the other areas, and in that respect it is the most strongly marked of them all. Some of the more important are as follows:

Arthopyrenia halodytes (Nyl.) Oliv.; Buellia halonia (Ach.) Tuck.; Dendrographa minor (Tuck.) Darbish.

Dirina franciscana A. Zahlbruckner, n. sp.—Thallus effuse, of thick, rounded, irregular tuberculate areoles, uniform crustaceous, sub-cartilaginous, forming heaped patches. Color varying from yellowish or brownish yellow to a dingy ashy gray, the last most common; K—; C—.

Apothecia numerous, of medium size, rounded elevated, sessile; surface of disk minutely granular, ashy-gray pruinose; the thalline margin thick, prominent, white, obtuse, soon flexuous, often intricately so; epithecium dark, 56 μ high; hypothecium black, thick, 140 μ high, blue or bluish with I; paraphyses typical of the genus, thecium wine-red with I; asci clavate, straight or curved, long-stalked, $\frac{70-134.5}{16.8-22.4}\ \mu$; spores eight, colorless, fusiform, straight or slightly curved, quadrilocular, $\frac{23.8-33.5}{5-8}\ \mu$.

On rocks 50 to 75 feet above the sea at Point Lobos, San Francisco, growing with *Dendrographa minor*.

Near *Dirina repanda* of Europe and Northern Africa, but with a thicker and differently colored thallus and with different spores.

Lecanactis Zahlbruckneri Herre, n. sp.—Thallus effuse, of small, irregular (sometimes plicate) squamules which at first are scattered but soon become a thick, uniform, tartareous crust. Color a more or less evident rose-pink which soon fades out in herbarium specimens, leaving them whitish or ashy gray.

Apothecia small, round, sessile, becoming convex; black, the disk gray-pruinose, but eventually naked; the proper margin prominent but finally excluded. Epithecium dark or black, thick, 45 to 50 μ high, blue with I; hypothecium black, broad, 42 to 60 μ high; paraphyses typical of the genus, thecium brick- or vinous-red with I; asci clavate, straight or curved, sometimes pointed at tip, $\frac{78-106}{16.8}\ \mu$; spores eight, colorless, fusiform, straight or slightly curved, quadrilocular, $\frac{19.6-28}{5-7}\ \mu$.

Rare on maritime rocks, 50 to 75 feet above the sea, at Point Lobos, San Francisco. Associated with *Dendrographa minor*, *Arthopyrenia halodytes*, and *Trentepohlia* sp.

Lecanora Bolanderi Tuck.; L. pinguis Tuck.; L. phryganitis Tuck.; Opegrapha saxicola Ach.; Parmelia Herrei A. Zahlbr.; P. Borreri Turn.; P. perlata (L.) Ach.; Pertusaria multipuncta (Turn.) Nyl.; Physcia erinacea (Ach.) Tuck.; Placodium coralloides Tuck.; Ramalina ceruchis (Ach.) DeNot.; R. ceruchis cephalota Tuck.; R. combeoides Nyl.; R. homalea Ach.; Rinodina radiata Tuck.

The foothill region comprises all that territory between San Francisco Bay and the mountains proper, south of San Bruno mountain, and extends from sea-level to a height of approximately 1000

feet. On the Pacific side it is either very narrow or non-existent, but on the eastern side of the peninsula it extends as far south as Monterey Bay. A park-like oak forest is characteristic of the lower part of the region, and on these trees is a lichen flora remarkable for its variety and luxuriance. While but few lichens are confined to this area, many reach here their greatest development. Probably every tourist is struck with the appearance of the "lace lichen," *Ramalina reticulata* (Noehd.) Krempelh., which decks the trees much as "Spanish moss" clothes the live oaks of the Gulf Coast. Other noticeable lichens are:

Collema nigrescens (Huds.) Wainio; C. vespertilio (Ltf.) Wainio; Evernia prunastri (L.) Ach.; Lecanora subfusca (L.) Ach.; L. varia (Ehrh.) Nyl.; Lecidea granosa Tuck.; L. granulosa phyllizans A. Zahlbr.; Leptogium chloromelum stellans Tuck.; L. palmatum (Huds.) Mont.; Pannaria lepidiota cyanolepra Tuck.; P. lepidiota coralliphora Tuck.; Parmelia soredica Nyl.; Placodium cerinum (Hedw.) Naeg. & Hepp.; P. ferrugineum (Huds.) Hepp.; Physcia pulverulenta isidiigera A. Zahlbr.; Ramalina Menziesii Tuck.; Theloschistes lychneus laciniosa (Schaer.).

The chaparral belt is not sharply delimited by contour lines or elevations, but depends upon climatic as well as physiographic features, the characteristic angiosperms of the chaparral being well-marked xerophytes. Hence we may have chaparral occurring on dry, barren hill-tops as low as four hundred feet, while we find more or less of it all the way to the summit of the Santa Cruz mountains. Very few lichens are exclusively chaparral, but where the conditions were favorable to such movement many conspicuous species have migrated from the adjacent forests. Certain components of the chaparral, such as the manzanitas, are almost wholly devoid of lichens ordinarily, because of their thick evergreen foliage and exfoliating bark. Others, as Ceanothus, Cercocarpus, and the scrub oaks, are conspicuous for their dense growth of lichens. The chief lichens in this formation are:

Cetraria californica Tuck.; Cladonia verticillata Hoffm.; Lecanora pallescens (L.) Schaer.; Parmelia enteromorpha Ach.; Ramalina farinacea (L.) Ach.; Usnea plicata (Ach.) Nyl.; U. dasypoga (Ach.) Nyl.; U. florida (L.) Ach.

The typical mountain forest of the Santa Cruz peninsula is the redwood and Douglas spruce formation, though much of the forested

area is given over to a growth of oaks, madrone, and other trees. In the redwood formation, sheltered by the dense canopy overhead, the lichens are but little affected by the frosts of winter, while the heavy summer fogs counteract the effect of the summer drouths. Having such favorable life-conditions for lichens, we may regard this region as the distributing center from which the chaparral has been stocked, while the foothill area has also largely been supplied in the same way. Arboreal forms such as the Stictaceae and certain Parmelias reach their highest vegetative and reproductive development in the dense redwood forests; while many others living on the earth or mosses are fertile and well grown only in the forests at 2000 feet or above, though they may descend in the foothills to as low as 150 feet. In this connection it may be well to call attention to the fact that the forests cover a much smaller area than formerly. For the last half-century the ax of the lumberman and forest fires have been actively engaged in the process of deforestation, and another generation may see many of the characteristic plants of the redwood forest extinct except within the limits of the Big Basin, which the state has purchased and set aside for a state park. Some of the more striking lichens of the forests are:

Alectoria jubata (L.) Tuck.; Cetraria ciliaris (Ach.) Tuck.; C. lacunosa stenophylla Tuck.; Cladonia macilenta (Hoffm.) Nyl.; Leptogium albociliatum Desmaz.; L. californicum platynum Tuck.; Nephromium helveticum Ach.; N. lusitanicum (Schaer.) Nyl.; N. tomentosum rameum Nyl.; Parmelia enteromorpha Ach.; P. perforata (Wulf.) Ach.; P. tiliacea (Hoffm.) Ach.; Peltigera canina membranacea (Ach.) Nyl.; Pertusaria Wulfenii DC.; Lobaria pulmonaria (L.) Hoffm.; L. scrobiculata (Scop.) DC.; Sticta anthraspis Ach.; S fuliginosa (Dicks.) S. Gray; S. limbata (Sm.) Ach.; Sphaerophorus globosus (Huds.); Usnea longissima Ach.; U. californica Herre.

By the mountain-peak area is meant the masses of exposed rock which may occur about the heads of heavily forested cañons, as well as the bare and rocky mountain peaks extending above the forests and chaparral. The lichens of this area are typically saxicolous, and while they may occur throughout the other formations wherever there is sufficient area of rock surface, some are found only along the highest mountains, swept by raw, bleak winds and exposed to a great diurnal as well as annual range of temperature. In summer this may rise to a sun temperature of 150° F. or more, and in winter may

descend to 20° F. or thereabouts, accompanied by more or less snow. These conditions of course can be met only by lichens specially adapted for such a life, of marked xerophytic structure, and there is no such enormous thalline development as is observed in the foothills or redwood formation. The lichen flora of this region, however, is not below that of any of the others in either number of species or of individuals. Important lichens of this region are:

Collema plicatile Ach.; Gyrophora diabolica A. Zahlbr.; G. phaea (Tuck.) Herre; G. polyphylla (L.) Turn. & Borr.; Lecanora muralis diffracta Fr.; L. calcarea (L.) Sommerf.; L. sordida (Pers.) Th. Fr.; L. upsaliensis Nyl.; Lecidea caeruleo-nigricans (Lightf.) Schaer.; L. auriculata Th. Fr.; L. polycarpa Fr.; Rhizocarpon geographicum DC.; Parmelia conspurcata (Schaer.) Wainio; Verrucaria terebrata (Mudd).

The lists published are merely some of the most conspicuous of each area and are by no means exhaustive. In the author's herbarium are more than 200 named species and sub-species of lichens which he has collected in the Santa Cruz region, with perhaps nearly a hundred more as yet unstudied or not satisfactorily determined. It is believed that the lichen flora of the region under discussion will be found to include more than 300 species and sub-species.

San José, California

BRIEFER ARTICLES

NEW NORMAL APPLIANCES FOR USE IN PLANT PHYSIOLOGY. IV[1]

(WITH TWO FIGURES)

In the three preceeding articles I have described seven new pieces of normal apparatus devised for educational work in plant physiology; and below will be found accounts of two more, to be followed later by others. I call them normal appliances because are they designed and made expressly for their specific work, yield approximately accurate quantitative results, can be used with economy of time and effort, and are obtainable at any time from the stock of a supply company, which in the present instance is the Bausch and Lomb Optical Company of Rochester, N. Y. The development of this apparatus is part of the present movement toward the elevation of educational plant physiology to a higher plane of scientific logic, accuracy, and efficiency.

VIII. RESPIROMETER

Respiration is a universal, and the most important, process of organic nature, and hence demands effective demonstration in all biological courses. Its study is the more valuable in plant physiology because, while respiration is essentially identical in plants and animals, it can be investigated far more readily in plants. Its central and crucial fact, energy-release, cannot be directly demonstrated by any known method, but indirectly it can be proven and its amount determined through the identification and measurement of the gases absorbed and released in the process. For this purpose many arrangements have been described, of all grades from complex and precise to simple and inaccurate. The present new instrument is designed both to exhibit and to measure the gas exchanges in typical respiring material (*e. g.*, germinating seeds), and to accomplish this with considerable accuracy and convenience of manipulation (*fig. 1*).

The respirometer consists of three parts. First is the stoppered oval chamber for the seeds, with a water bulb at the bottom. Second is the measuring cylinder in open communication with the chamber, graduated from 75^{cc} to 100^{cc} of the combined capacity of itself and chamber, though the 75^{cc} mark is actually placed at 77^{cc} of the capacity. Third, and

[1] Continued from BOT. GAZETTE 41:213. March 1906.

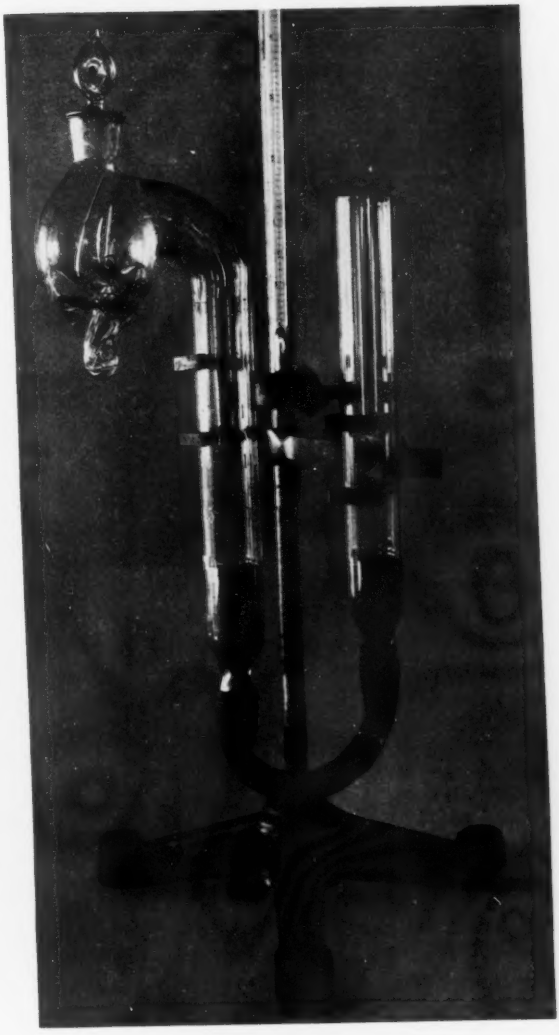


FIG. 1.—Respirometer.

communicating with the preceding through a slender rubber tube, is the reservoir cylinder, ungraduated but with index marks 25^{cm} apart. Both tubes are supported vertically by any convenient laboratory clamps which permit the reservoir tube to be slipped up and down.

For demonstration purposes it is best to select seeds in which the oxygen absorbed and the carbon dioxid released are as nearly as possible equal in volume, *e. g.*, oats. Ten of these of average size are soaked, or better, are selected from a lot which have been started in a germinator until the roots are about 5^{mm} long; they are then placed in the chamber, root ends down, just above the bulb, where they will stick if previously wetted. These occupy approximately 1^{cc} of volume; and if now 1^{cc} of water be placed in the bulb, there will be 2^{cc} of these materials and 100^{cc} of air, the composition of which is of course known, above the zero mark. Where greater accuracy is desired, it may be attained by first dropping the ten seeds into a proper measuring-glass, then filling this with water to the 2^{cc} mark, and finally placing both seeds and water in the chamber. The index liquid to be used is now poured through the reservoir tube until it stands level at the 100^{cc} mark of the graduated tube and at the upper index mark of the reservoir (or the lower when mercury is used). The stopper, properly lubricated, is inserted with its air opening matching that of the neck, and is then twisted, thus sealing the chamber without any compression of air. The apparatus is now shielded from light and placed under proper conditions for growth.

For the most effective educational demonstration it is desirable, though not necessary, to use two of the respirometers. In one is placed a strong solution of caustic potash, which rises steadily, as the seeds grow, to near the 21 per cent. mark and then stops. This proves that some gas has vanished from the tube, and the amount suggests oxygen. In the other mercury is used, and the constant level it maintains proves that for any gas absorbed by the plants an equal volume of some other has been released. Since however caustic postash absorbs only carbon dioxid, it is plain that the gas released must be carbon dioxid, while the gas absorbed is presumably oxygen. If it is thought this latter point still needs proof, it can be supplied by a third instrument using pyrogallate of potash. This promptly absorbs all oxygen, and the failure of the seeds to grow shows that oxygen is the gas absorbed in the other instruments. If but one instrument is available, it is best to use it with mercury, and, after the seeds have been growing for some three or four days, to make an analysis of the gas by the method earlier described[2] for the photosynthometer. The reservoir and

[2] BOT. GAZETTE 41:211. 1906.

rubber tubes are slipped off under water, allowing the mercury to run out, and are then used as a reagent tube, the reservoir being stoppered for the purpose.

When plant parts in which the respiratory ratio is not 0 are studied, a preliminary test is made to ascertain in which direction the ratio varies, and then the starting-level can be adjusted accordingly.

The usual corrections of course must be made. The gas pressure inside at the time of reading is equalized with the atmospheric pressure by sliding the reservoir tube up or down until the levels inside and out are equal. For very exact work it would be necessary to take account of the barometric pressures, but the slight error of this sort is negligible in demonstration. The temperature must either be made the same at the start of the experiment and the final reading; or else, as is readily possible, the change of volume due thereto must be calculated. Vapor tension should also be considered in exact work, but it is negligible in demonstration. After each use the instrument should be thoroughly washed clear of potash.

IX. NORMAL LIGHT SCREENS

In several phases of the study of photosynthesis it is necessary to apply some form of light or color screen to a leaf. To this end various arrangements are extemporized which, however inconvenient and time-consuming to prepare, are scientifically unexceptionable so long as they are physiologically accurate. But unfortunately some of these devices are logically fallacious and yield results which are only accidentally correct. This is true, for example, of that experiment common in elementary demonstration, where disks of cork, tin-foil, etc., are placed matching on opposite sides of the leaf in order to exclude light; in fact, they also exclude the equally indispensable carbon dioxid.

Screens correct in principle must allow for free access and exit of gases, but in their construction advantage may be taken of the fact that in ordinary leaves the stomata are either largely or wholly on the under surface, so that if this is left free the upper surface may be covered as closely as desired. It is upon this principle the two forms figured herewith (*fig. 2*) are constructed. The larger, designed to take an entire leaf of moderate size, consists of a wooden box readily adjustable for height and angle, $5 \times 7 \times 1\frac{1}{4}$ inches (internal), white without and black within, separated lengthwise into two compartments with an intermediate space for petiole and midrib. The bottoms of the compartments are largely open, but so matched by diaphragms that air can enter freely but no direct light. Movable gratings of silk threads hold the leaf firmly but elastically against the glass cover,

which may be either two separate strips covering the compartments and therefore the halves of the leaf, or a single sheet 5×7 inches in size. The cover may then carry tin-foil, cut with any desired pattern, gummed to its under surface; or it may carry vials of pure colors correlative to the light and dark spots of the chlorophyll spectrum (as was the case when the accompanying photograph was taken); or it may be replaced by a 5×7 negative for Gardiner's striking starch-printing experiment. The arrangement does not of course permit as free access of carbon dioxid as the uncovered leaf enjoys, but this is only a matter of degree and does not affect the result when sufficient time is allowed for the experiment. In using

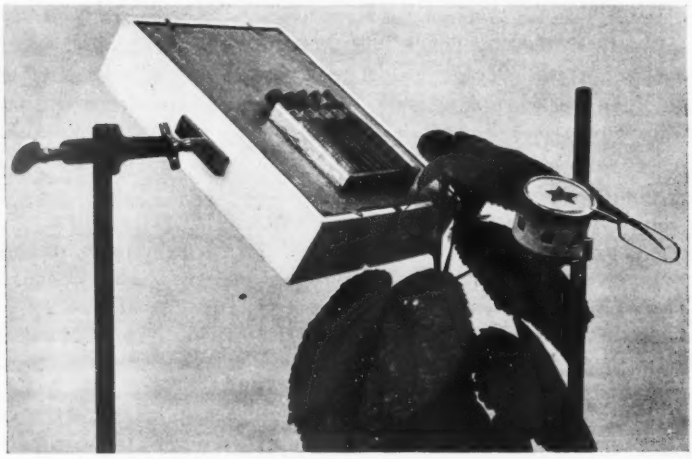


FIG. 2.—Normal light screens.

this, as any other, light screen it is desirable to expose the plants not to direct sunlight but to strong diffused light, which is nearer the optimum and has less heating effect. The leaves of course are subsequently blanched and treated with iodin in the usual manner.

The smaller screen, of a less range of usefulness but much cheaper, is made upon the same general principle except that it is constructed to clasp a portion of a leaf. A spring clip holds a glass disk against the upper surface of a leaf, which is supported below by a grating of threads stretched across the top of a ventilated dark box. The glass is removable from the clip and may carry a tin-foil screen cut with a pattern and gummed to its under surface as in the figure; or it may be used to hold a photographic

negative (film or glass) against the leaf, in either case permitting a very striking demonstration of the need for light in photosynthesis.

Both instruments appear to be correct in principle; both are convenient and efficient in manipulation; and they yield most satisfactory results. —W. F. GANONG, *Smith College, Northampton, Mass.*

IS THIS BIRCH NEW?

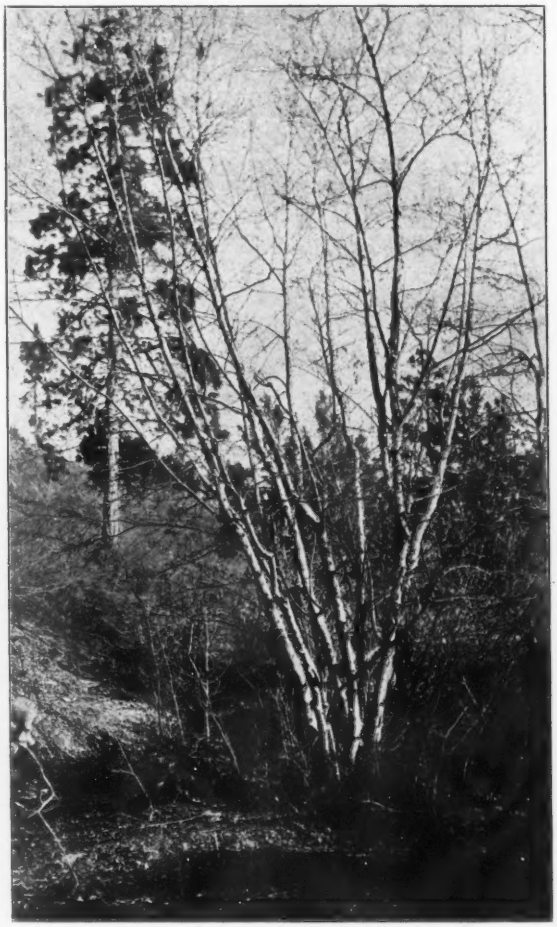
(WITH ONE FIGURE)

The paper birch (*Betula papyrifera* Marsh.) has never been reported from Colorado. The nearest region to Colorado from which authentic specimens have been obtained is probably the Black Hills in northwestern Wyoming and adjacent South Dakota. It was therefore a great surprise when Mr. D. M. ANDREWS of Boulder, Colorado, reported finding a birch which in many respects resembles *B. papyrifera*. He writes of it as follows: "About three miles from Boulder on the north slope of Green Mountain, altitude 6500–7000 feet, I find one hundred trees, more or less, of the species from which I send you specimens."

An examination of the material sent, which, by the way, was secured so late in the season that the specimens are not in good condition, indicates its affinity to *B. papyrifera*. It cannot be referred to the var. *cordifolia*, and it is even less like typical *B. papyrifera*. In the material so far available, however, it is difficult to point out specific distinctions. From the latter it differs in the darker bark, which on the trunk is marked by long transverse rifts (lenticels). The current season's twigs of ANDREWS' specimens are light brown, the two-year-old twigs more or less grayish, and the older branches reddish brown and distinctly marked by the white oval lenticels. The bark on the main trunks is silvery gray, materially darker than in *B. papyrifera*, though it peels readily into layers as in that species. The leaves do not seem to differ essentially, being either broadly cuneate or rounded at the base. The margin is rather sharply and irregularly serrate, though the teeth are not long. The apex is somewhat abruptly short-acuminate. The bracts of the fruit are deeply 3-lobed, the central lobe being longer and narrower than the lateral. The nut is oblong-obovate, with very thin wings nearly twice as broad as the body.

Its habit is perhaps its strikng character. In *B. papyrifera* there is usually a single trunk, which branches above in true tree fashion. ANDREWS writes of his birch as follows: "You will notice the uniform tendency to form clumps or stools, which is true of quite young specimens. The

photograph of the older clump shows trunks about six inches in diameter, which seems to be the maximum, after which the old trunks die and are



Betula, n. sp. ?, showing characteristic habit; collected near Boulder, Colorado, by D. M. Andrews.

replaced by young sprouts from the same root. While the difference in size (between this and *B. papyrifera*) may be due to differences of environ-

ment, I do not believe it to be entirely so, and suspect that in cultivation they would remain distinct, age for age, *B. papyrifera* growing more rapidly."

Further studies another season may show other characters that will absolutely separate this newly found birch from *B. papyrifera*. Should such be the case, the writer will then propose the name **Betula Andrewsii** for this new find, in honor of Mr. ANDREWS, whose diligent studies and discriminating observations in the field are again recognized—studies the more valuable because the opinions formed in the field are usually verified in his experimental and nursery grounds at Boulder.—AVEN NELSON, *University of Wyoming, Laramie.*

RHODODENDRON ALBIFLORUM WITH DOUBLE FLOWERS

While on a botanizing tour with Mr. J. G. JACK in British Columbia in the summer of 1904, we were staying several days at Glacier, the station of the Canadian Pacific R. R. close to the foot of the Great Glacier of the Selkirks, to explore the surrounding country. Just above the hotel in the Asulkan valley there is a grove of *Tsuga Mertensiana* and *T. heterophylla*, through which a path leads to the foot of the glacier. As I left this path to cross a thicket of small hemlocks to the bank of the Asulkan River, I noticed close to the brink of the river a large shrub of *Rhododendron albiflorum* in full bloom which at once attracted my attention, as all other shrubs of this species were past flowering; and I was very much astonished to find on coming nearer that it bore large white double flowers very much like those of the double cherries sometimes cultivated in gardens. It was a strange sight in these wild and rough mountain woods to see such blossoms which one associates involuntarily with the finished surroundings of a well-kept garden. What agency caused the origin of such a form? Close by grew the typical form, and there was nothing unusual in the place or position where the shrub grew, nor in the shrub itself aside from its double flowers. This is probably the first time that a double-flowered Rhododendron has been found in this country. Though reports of the occurrence of double-flowered plants in a wild state are not wholly lacking, they are nevertheless rare. In the European Alps *Rhododendron ferrugineum* has been found at least twice with double flowers, as reported by A. KERNER (Oesterr. Bot. Zeits. **15**:285. 1865), who himself found in one locality a large number of shrubs with double flowers.

As in most double flowers, the cause of this teratological aberration is in this case petalody of stamens combined with a considerable increase

in the number of the staminal whorls. Calyx and corolla present the normal condition, while the stamens have taken the shape of petals. Though the ten stamens belong to two whorls, the petalodes are more or less connate at the base into 10-merous whorls; but the petalodes of all the whorls are in superposition, showing thus that they must be considered as consisting of alternate 5-merous whorls, and this is also apparent by the aestivation of the broader petalodes of the outer whorls; the first five petalodes, of course, are opposite to the corolla lobes, as the ericaceous flower is obdiplostemonous. The number of 10-merous whorls in each flower is about ten; the shape of the petalodes changes from the broadly oval of the outer ones to the oblong shape of the innermost petalodes. Even the carpels are changed into narrow oblong petalodes. Only in one case I found an incompletely developed anther adhering to one of the petalodes.

As it would be interesting to have this shrub in cultivation, though the horticultural value of this form is lessened by the rather difficult cultivation of the species, we sent rooted suckers to the Arnold Arboretum, but the plants did not survive, and concerning the fate of a few sent to a German nursery I know nothing. The old plant, however, is in all probability still there, and we may yet hope to see this handsome form introduced into cultivation. Dried specimens of it are preserved in the herbarium of the Arnold Arboretum.—ALFRED REHDER, *Arnold Arboretum.*

PUCCINIA UPON MELOTHRIA

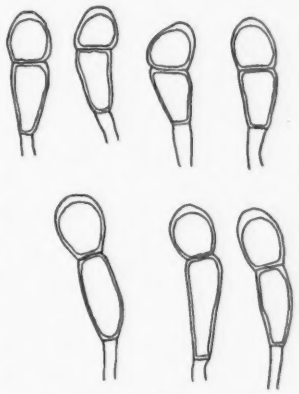
(WITH ONE FIGURE)

This rust was found in the neighborhood of West Raleigh, N. C., in the autumn of 1907 upon *Melothria pendula.* The host is not a common plant in this locality, only two plants being seen during an entire collecting season; one of these was thoroughly infected, the other not at all.

The species is of special interest on account of the comparative paucity of rusts affecting the cucurbits, as well as owing to the economic importance of this family. On the whole family as represented by the North American genera, either native or exotic, listed in SMALL'S *Flora of the South Eastern United States,* GRAY'S *Manual,* GRAY'S *Field, Forest,* and *Garden Botany,* and BRITTON and BROWN'S *Illustrated Flora,* there are mentioned in FARLOW'S *Host Index* no rusts at all. In SACCARDO there are six species, as follows: (1) *Uromyces Melothriae* on *M. tomentosa* in Abyssinia; (2) *U. Cayaponiae* on *C. racemosa* in Africa; (3) *U. Hellarianus* on *Cayaponia* in Porto Rico; (4) *Puccinia Cucumeris* on *C. ficifolia* in Abyssinia; (5) *P.*

Momordicae on *M. cordifolia* in Natal; (6) *Aecidium Momordicae* on Momordica in Brazil.

The Puccinia upon *Melothria pendula* is different in shape, color, and size of spores from *P. Cucumeris* and from *P. Momordicae*, and seems clearly to be an undescribed species. The germination of the teleuto-spores occurs freely in the older sori, placing the rust among the Leptopucciniae. The following description is proposed.



Puccinia Melothriae, n. sp.

Puccinia Melothriae, n. sp. — III. Teleutosori: hypophyllous, crowded in irregular concentric circles, pustular, soon naked, pulverulent, cinnamon-colored (no. 32 Sacc.), cinereous on germination, ruptured epidermis inconspicuous; spots pale, indefinite. Teleutospores: hyaline to straw-colored (no. 26 Sacc.), 40–52 × 10–16 μ; slightly or not at all thickened at apex, often not constricted at septum, wall about 2 μ thick, smooth. Terminal cell usually round, rarely oblong, 10–16 × 12–20 μ. Basal cell wedge-shaped, 10–15 × 20–30 μ. Pedicil 20–45 μ long, hyaline. Germination immediate; that of the terminal cell by an apical promycelium, that of the basal cell by a lateral promycelium.

On *Melothria pendula* L., West Raleigh, N. C., 9–15–06, *F. L. Stevens* and *J. G. Hall*, type no. 471.—F. L. Stevens, *West Raleigh, N. C.*

AN INSTANCE OF MUTATION

Euphorbia marginata Pursh, commonly called in Colorado "snow-on-the-mountain," is easily recognized by its white-margined upper leaves or bracts, and the five white appendages of the floral glands. In the splitting up of the old genus Euphorbia, it has been referred to a genus *Dichrophyllum* Kl. & Garcke, and distinguished from *Tithymalus* Adans by the characters just mentioned. In Tithymalus there are but four glands, with rudiments of the fifth. All authors seem to agree that *E. marginata* has five glands; "three" in Britton and Brown, *Ill. Flora* **2**:376, is a mere misprint, as the figure shows. Having recently had occasion to examine *E. marginata* at Boulder, Colorado, I have been astonished to find that *four* glands is normal in this locality, and a plant with *five* glands

has not been seen. One large plant deviated still more, showing mostly *three* glands, and the white margins of the leaves very narrow. I wrote to Professor AVEN NELSON about this, and he replies "all Colorado specimens do not show the reduction in number which you mention, and some of the specimens are quite devoid of white on the margins of many of the leaves." We seem to have a clear case in which a new race has been formed by mutation, or more precisely the *meristic variation* of BATESON. Incidentally it seems fairly evident that the genus Dichrophyllum cannot be maintained; so we have:

Tithymalus marginatus (*Euphorbia marginata* Pursh, 1814);

T. marginatus tetramerus, var. nov., the Boulder race with four glands.—

T. D. A. COCKERELL, *University of Colorado, Boulder.*

CURRENT LITERATURE

MINOR NOTICES

Das Pflanzenreich.[1]—Part 27 contains the Polemoniaceae by A. BRAND, a family of peculiar interest to North American botanists. The author defines two subfamilies, COBAEOIDEAE and POLEMONIOIDEAE, the former containing Cantua and Cobaea, the latter the other ten genera. The genera and the number of their species are as follows: Cantua (6, with 2 new), Cobaea (9), Polemonium (29, with 3 new), Collomia (12), Phlox (49, with 9 new), Gilia (111, with 12 new), Aliciella (1), Gymnosteris (1), Navarretia (41, with 7 new), Langloisia (5, with 1 new), Loeselia (12), Bonplandia (1). The full synonymy and citation of collections, the elaborate splitting-up of the species into subspecies, varieties, and subvarieties, and the excellent illustrations, make the monograph a mine of information for students of the family. This careful traversing of American taxonomic work from the European standpoint is most instructive, and helps to focus attention upon our differences.—J. M. C.

Tylostomeae.—This "very natural tribe" of Gasteromycetes is described by LLOYD in a separately printed pamphlet,[2] which is dedicated to M. P. HARIOT, whose portrait forms its frontispiece. LLOYD recognizes seven genera, of which five are monotypic, Tylostoma containing the most of the species. All are illustrated by good photographs.—C. R. B.

NOTES FOR STUDENTS

Monograph of Ravenelia.—A valuable contribution to the literature of the rusts has appeared in DIETEL'S[3] monograph of the genus Ravenelia. In the past, investigations relating to this peculiar genus have been necessarily of a more or less fragmentary nature, dealing with the morphology and taxonomy of a limited number of species only. Since the last monograph[4] which is at all comprehensive, a number of new species have been added to the genus from different parts of the world. On this account a full morphological and taxonomic treatment is especially desirable. The present paper is introduced by a discussion of

[1] ENGLER, A., Das Pflanzenreich. Heft 27. Polemoniaceae von A. Brand. pp. 203. *figs. 39 (207)*. Leipzig: Wilhelm Engelmann. 1907. *M.* 10.20

[2] LLOYD, C. G., The Tylostomeae. 8vo. pp. 29. *pls. 12. figs. 6.* Cincinnati, O.: The author. 1906.

[3] DIETEL, P., Monographie der Gattung *Ravenelia* Berk. Beih. Bot. Centralbl. **20**:343–413. *pls. 5–6.* 1906.

[4] DIETEL, P., Die Gattung Ravenelia. Hedwigia **33**:22–29, 367–371. 1894.

the morphology of the genus. In general the mycelium, aecidiospores, and uredospores offer no striking characters different from other rusts; a few points of interest, however, are noted. The mycelium is usually intercellular and nourished by haustoria; but in some species it penetrates the cells, and in *R. atrocrustacea* on Swartzia it penetrates the vessels, developing abundantly within them. In several species the mycelium is perennial. Aecidia occur in only a few species and present no unusual peculiarities. The uredospores correspond to those of other rusts; but in the species on Cassia the uredospores are formed between the epidermal wall and the cuticle.

The teleutospores, which constitute the most interesting spore-type, are treated with some detail. A great many modifications exist as to the number of cysts, spores, and hyphae making up the spore-heads; but the author has arranged these into types within which the mode of building up the spore-head is remarkably uniform. These types are briefly as follows: (1) all spore-heads have a definite number of stalk-hyphae, which is uniform for each species, and each hypha gives a definite number of outer and inner spores; (2) the number of hyphae bearing the spore-heads is variable, but each hypha bears a definite number of spores, which is uniform within each species; (3) there is no uniformity in the number of hyphae and spores; the simplest forms of this last type have a single stalk-hypha which bears several spore-cells.

Heretofore the genus Ravenelia has been regarded as related to Puccinia, but on account of the occurrence of longitudinal divisions in the heads, DIETEL thinks the genus bears a closer relationship to the genera Diorchidium, Anthomyces, and Sphaerophragmium.

In the purely taxonomic part of the work 81 species are described, all of which are placed in the genus Ravenelia. The genera Pleoravenelia and Neoravenelia, recently separated from Ravenelia by LONG, are not retained, being considered insufficiently distinct. The author divides the genus into two sections: Haploravenelia and Pleoravenelia, the former comprising Ravenelia of LONG. —H. HASSELBRING.

Bacteria and mineral salts.—BENECKE,[5] in an investigation of the pigment-producing powers of *B. pyocyaneus* and *B. fluorescens*, lays emphasis upon the need of careful purification of chemicals and selection of glass receptacles in bacteriological experiments with synthetic media. He used several kinds of glass control, including quartz, which is too expensive for general use, Jena glass which is K-free but contains Mg, resistance glass, Vienna glass which is probably Mg-free, Bohemian glass, and ordinary glass. With the various flasks he could obtain practically all the contradictory results of previous investigators, such as NOESSKE, THUM, JORDAN, GESSARD, SULLIVAN, and LOEW. By means of the controls he could trace most of the discrepancies in their results to impurities of chemicals or glassware. BENECKE'S chemicals were washed and recrystallized

[5] BENECKE, W., Untersuchungen über den Bedarf der Bakterien an Mineralstoffen. Botanische Zeitung **65**: 1–23. 1907.

from 3–6 times in Jena glass or in platinum dishes; the water was redistilled and kept in Jena or in Thüringen glass. The most important of BENECKE'S results, and those in which he is at variance with the investigators mentioned above, are as follows: (1) Dextrose or ammonium salts cannot be substituted for asparagin in the simple solution, asparagin 0.25 per cent., magnesium sulfate 0.05 per cent., potassium phosphate 0.02 per cent. (2) Potassium is necessary for development, although a very small amount of K-ions suffices for growth and pigment production. (3) Potassium cannot be replaced by lithium, sodium, or ammonium. It can be replaced by rubidium and caesium, though not to the same degree, the presence of 0.0000015 per cent. of KCl being sufficient for development, while RbCl must be 10 times, and CsCl 100 times, as strong. The latter are also more toxic than KCl in concentrated solutions. (4) The presence of magnesium in the solution is necessary for development. Growth occurred in Mg-free solutions in Jena glass, which has 5 per cent. Mg in it, while no growth was obtained in Vienna glass. This Mg relation has been a stumbling-block for many investigators. On the other hand, the conclusion of most of the other authors that phosphate is essential in the solution is confirmed by BENECKE, as is also the observation of JORDAN and of NOESSKE that the acid group SO_4 is necessary for pigment development in *B. fluorescens* and *B. pyocyaneus*. BENECKE, however, does not distinguish between the two pigments produced by the latter organism, which may not be alike dependent upon sulfate.—MARY HEFFERAN.

Infectious chlorosis.— Further studies of BAUR[6] on the infectious chlorosis of the Malvaceae have shown that green shoots which occasionally appear on variegated plants of *Abutilon Thompsoni*, Hort., are entirely immune to the disease and remain so. If a scion from one of these immune shoots is grafted upon a variegated plant, the scion produces only green leaves. If another scion of a green susceptible variety is grafted upon the first, the second scion will become variegated, showing that the virus is conducted unchanged through the immune piece. If, however, the experiment is conducted by using the immune species *Lavatera arborea* L. as the intermediate piece, no infection occurs in the second scion. In the first instance the intermediate plant is immune but does not affect the virus; in the second instance the virus is evidently destroyed. In his former paper BAUER showed that the virus causing chlorosis was developed only in the light. In the present paper the light relation is more fully investigated. It is found that somewhat shaded individuals, as when growing under shrubbery, lose their variegation, although growth is not greatly influenced. The optimum for virus formation, therefore, lies much above that for growth. Although shading the plants resulted in a diminution of the white areas, it was not possible by increased illumination to increase the areas above a certain maximum which

[6] BAUR, ERWIN, Weitere Mitteilungen über die infectiöse Chlorose der Malvaceen und über einige analoge Erscheinungen bei Ligustrum und Laburnum. Ber. Deutsch. Bot. Gesells. **24**:416–428.

seems to be attained at ordinary illumination. This seems to indicate that even the green areas of infected leaves are permanently immune to the variegation. Both in blue and in red light plants retained their variegation.

BAUR has extended his investigations to other variegated plants and finds that infectious chlorosis is of widespread occurrence. Both true variegation and the infectious form may occur in varieties of the same species. Among the forms investigated, a variety of *Ligustrum vulgare L.* and one of *Laburnum vulgare* (Griseb.) owed their variegation to infectious chlorosis similar to that of *Abutilon Thompsoni*, Hort.—H. HASSELBRING.

Hydrocyanic acid in plants.—GUIGNARD has been giving special attention to plants which contain glucosides that produce this acid, and the conditions under which they may become poisonous. He relates in one paper[7] the cases of poisoning from the use of beans derived from wild or subspontaneous forms of *Phaseolus lunatus* L., a species having many forms, of which our Lima bean is one. In cultivation these are generally quite innocuous, but all contain phaseolunatin in greater or less quantity, which is split by emulsin into glucose, acetone, and hydrocyanic acid. The beans from Java have proved most virulent. A botanical and chemical history of the species is given, with illustrations of the seeds of many varieties. A new, convenient, and certain mode of detecting the acid is proposed. Filter paper is moistened with 1 per cent. picric acid and dried, then moistened with 10 per cent. sodium carbonate and dried, in which state it keeps its sensitiveness several months. A strip suspended in a test tube containing 0.02–0.05^{mg} HCN becomes red-orange in 12–24 hours.

In other papers[8] Guignard notes the presence of a cyanogenetic compound in *Sambucus nigra* L., *Ribes rubrum* L., *R. aureum* Pursh., where it is found in the fresh leaves from vigorous shoots, green fruits, and young bark of the stem, while traces appear elsewhere. The compound is probably a glucoside that is split by emulsin, which accompanies it and does not seem to be a reserve food.[9]

Emulsin he reports in the aerial roots of a considerable number of exotic and indigenous orchids,[10] and also in certain yeasts[11] (resembling *Sac. Pastorianus* Hansen). This has also been announced by HENRY and AULD.[12]

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[7] GUIGNARD, L., Le haricot à acide cyanhydrique (*Phaseolus lunatus* L.). Revue de Viticulture **1906**. *col. pl. 1. figs. 9.*

[8] ———, Sur l'existence, dans le sureau noir d'un composé fournissant de l'acide cyan-hydrique. Bull. Sci. Pharmacol. **12** and **13**. 1905–6.

[9] ———, Nouvelles observations sur le formation et les variations quantitatives du principe cyanhydrique de sureau noir. *Idem.* See also announcements in Compt. Rend. Acad. Sci. Paris June 3, July 24, Sept. 4, Dec. 26, 1905.

[10] ———, Quelques faits relatifs à l'histoire de l'émulsine; existence générale de ce ferment chez l'Orchidées. *L. c.* footnote 8.

[11] ———, Secretion d'émulsine par les levures. *L. c.*

[12] Proc. Roy. Soc. B. **76**:568. 1905.

In the latest note[13] GUIGNARD adds a considerable number of Rosaceae, of the tribes Pruneae and Spiraeae, whose leaves and other parts furnish hydrocyanic acid.—C. R. B.

Sexuality of the Uredineae.—In 1904 BLACKMAN[14] showed that a peculiar process of fertilization occurs in the aecidium of *Phragmidium violaceum*, by which a nucleus from a vegetative cell of the mycelium migrates into a fertile cell, and thus brings about the condition of paired nuclei found by SAPPIN-TROUFFY[15] to be quite universal in the teleutospore-bearing mycelium. Two questions naturally arise as a result of this work. First, since the aecidium of *P. violaceum* is of a special type, how far will this process of fertilization be found to explain the origin of conjugate nuclei in aecidia generally? Second, what process takes place in those forms which have no aecidium? Both of these questions BLACKMAN and FRASER[16] attempt to solve in a later contribution to the cytology of the Uredineae. In *Uromyces Poae* Raben. and *U. Poarum* Neil., both of which are *eu*-forms with typical aecidia, the migration of nuclei from one vegetative cell to another was observed in the tissue of the aecidium. These migrations were not so easily distinguished as in *P. violaceum*. In *Melampsora Rostrupi* Wagn., which has aecidia of the caeoma type, no fertilization was discovered, but there were some evidences that fertilization took place in the manner described by CHRISTMAN for *Phragmidium speciosum*. In *Puccinia Malvacearum* Mont., a *lepto*-form, the change from uninucleate to binucleate cells takes place in the hyphae of the teleutosorus, but the exact method could not be determined; neither could the transition be made out in the *micro*-forms *P. Adoxae*, D. C., *U. Scillarum* Wint., and *U. Ficariae* Lév.—H. HASSELBRING.

The filiform apparatus.—Striations on the micropylar portion of synergids were described in 1856 by SCHACHT, who called them "fertilization threads" (*Befruchtungsfaden*); HOFMEISTER gave the name "filiform apparatus" (*Fadenapparat*); STRASBURGER in 1882 believed the lines or threads consisted of fine pores. A paper by HABERMANN[17] now brings modern technic and modern lenses to bear upon the subject. The filiform apparatus, more or less developed, is characteristic of angiosperms generally. The apparatus arises by the transfor-

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[13] ———, Nouveaux exemples de Rosacées à acide cyanhydrique. Compt. Rend. Acad. Sci. Paris **143**:451. Oct. 1. 1906.

[14] BLACKMAN, V. H., On the fertilization, alternation of generations, and general cytology of the Uredineae. Annals of Botany **18**:323–373. *pls. 21–24.* 1904.

[15] SAPPIN-TROUFFY, P., Recherches histologiques sur la famille des Uredinées. Le Botaniste **5**: 59–244. *figs. 68.* 1896–7.

[16] BLACKMAN, V. H., and FRASER, MISS H. C. I., Further studies on the sexuality of the Uredinaceae. Annals of Botany **20**:35–48. *pls. 3–4.* 1906.

[17] HABERMANN, ALFRED, Der Fadenapparat in den Synergiden der Angiospermen. Beih. Bot. Centralb. **20**:300–317. *pl. 13.* 1906.

mation of the foam-like cytoplasm, its growth continues by apposition, and the upper portion often swells considerably before fertilization. The membrane of the embryo sac is resorbed over the apex of the synergids, which then quite frequently protrude. The vacuoles in the lower part of the synergids develop simultaneously with the filiform apparatus, and are separated from it by a plasma membrane. The filiform apparatus consists of cellulose, and its function seems to be the separation of the chemotactic glucose-containing substance, which passes into the micropyle and attracts the pollen tube. The name "synergid" is consequently quite appropriate.—CHARLES J. CHAMBERLAIN.

Moisture in seeds.—BROWN and DUVEL[18] have devised a method for the rapid determination of the percentage of moisture in grains. The method consists in heating a given weight of the grain in oil to drive off the water, which is condensed and measured in a graduated cylinder. The method is accurate, simple, and capable of great speed in application. The determinations are said to be accurate to 0.1 of 1 per cent., which makes it suitable for all scientific determinations. A determination can be made in twenty minutes, and with a number of compartments to the apparatus one trained manipulator with an ordinary assistant can make 200 determinations in a day. It is to be hoped that this will be one step toward putting grain-testing on a reliable basis. The economic improvement in the method of grading grain is seen when it is mentioned that the percentage of the European importation of corn that the United States furnishes has greatly diminished in the last decade, because of the great liability of our corn to spoil *en route*.—WM. CROCKER.

Centrosomes in angiosperms.—KOERNICKE[19] has reviewed the centrosome studies of the past seven years, paying particular attention to the work of BERNARD. Besides studying his old preparations and making new ones showing mitosis in the embryo sacs and pollen mother cells of various species of Lilium, KOERNICKE has made a thorough study of the division of the generative cell as it occurs in the pollen tube of Lilium, thinking that centrosomes might be retained longest by these structures which represent the ciliated sperms of some gymnosperms. No centrosomes were found, but on the contrary the fibers of the spindle were seen to end in the *Hautschicht*. It is of interest to note that while the generative cell is sharply outlined in the pollen grain, it loses its sharp contour after it passes into the pollen tube. After the generative nucleus divides, the two daughter nuclei lie free in the general cytoplasm of the pollen tube, there being no well-organized cells as figured by GUIGNARD and reproduced by current textbooks.—CHARLES J. CHAMBERLAIN.

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[18] BROWN, EDGAR, and DUVEL, J. W. T., A quick method for the determination of moisture in grain. U. S. Dept. Agric., Bureau Pl. Ind., Bull. 99. pp. 24. *figs. 12.* 1907.

[19] KOERNICKE, MAX, Zentrosomen bei Angiospermen. Flora **96**:501–522. *pl. 5.* 1906.

A birch rope.—D. P. PENHALLOW has described[20] a remarkable growth occurring upon a specimen of *Betula populifolia* found in the New Brunswick woods. It is a rope-like structure, reported to have been at least twenty feet long and approximately 1×0.4^{cm} in diameter, and hanging free. The anatomical study showed that the growth had its origin in a lesion of the living bark. The traumatic reaction, instead of becoming localized and forming wood or sclerotic tissue, continued its development as active parenchyma and forced its way through the overlying and external tissue of the periderm. The form of the outgrowth suggests that it emerged through a lenticel. The outgrowth may be regarded as a special form of tumor, which developed by simultaneous division throughout its entire length and completed its growth in one season. The formation of cork proceeded over the entire surface until the final exhaustion of the parenchyma.—J. M. C.

Homology of the blepharoplast.—IKENO[21] replies to those who have questioned the correctness of the conclusion set forth in his paper on spermatogenesis in *Marchantia polymorpha*, and reasserts his belief that the blepharoplast is a centrosome. He admits, however, that the centrosome may be absent during the development of spermatogenous tissues in the higher liverworts, and may appear only as the blepharoplast. He thinks that the bodies now called blepharoplasts may not be homologous structures, and suggests three categories: (1) centrosome-blepharoplasts, which are either ontogenetically or phylogenetically of centrosome origin; here belong the blepharoplasts of myxomycetes, liverworts, pteridophytes, and gymnosperms; (2) plasmodermal blepharoplasts, as in Chara and some Chlorophyceae; and (3) nuclear blepharoplasts, as in some genera of flagellates.—CHARLES J. CHAMBERLAIN.

The dwarf males of Oedogoniaceae.—A reinvestigation of this subject has brought PASCHER[22] to conclusions somewhat different from the commonly accepted views. The egg is regarded as a modified zoospore, the clear receptive spot corresponding to the hyaline ciliated area of the zoospore. The androzoospore (androspore of PRINGSHEIM) represents an intermediate development between the zoospore and spermatozoid. Accordingly the gynandrous and the macrandrous-dioecious forms of the Oedogoniaceae have advanced farther along the line of sexual differentiation than have the forms with dwarf males. The dwarf males of the Oedogoniaceae are homologous with the dwarf sporelings of the Chaetophoraceae and show more relationship with forms like Chaetophora than with forms like Ulothrix.—CHARLES J. CHAMBERLAIN.

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[20] PENHALLOW, D. P., A birch rope; an account of a remarkable tumor growing upon the white birch. Trans. Roy. Soc. Canada II. **12**:239–255. *figs. 9.* 1906.

[21] IKENO, S., Sur Frage nach der Homologie der Blepharoplasten. Flora **96**: 538–542. 1906.

[22] PASCHER, ADOLF, Ueber die Zwergmännchen der Oedogoniaceen. Hedwigia **46**:265–278. 1907.

Secondary thickening in pteridophytes.—The known cases of secondary thickening in recent Pteridophyta have been brought together by HILL[23] in a useful résumé. After stating the criteria for secondary growth, Botrychium, which has a distinct cambium, and Ophioglossum, which lacks a definite layer, are described, followed by Angiopteris and Marattia, in which a cambium forms a few xylem elements. CORMACK'S observations on the secondary wood in the nodes of Equisetum are cited, though no reference is made to the cambium in the young cone as reported by JEFFREY.[24] The other cases of secondary growth include Psilotum, *Selaginella spinulosa*, and several species of Isoetes, especially *I. hystrix*, which may show a cambium outside the vascular cylinder.—M. A. CHRYSLER.

The cell wall.—Whether isolated portions of protoplasm without nuclei are capable of surrounding themselves with walls or not has long been in dispute. Nearly twenty years ago PALLA claimed that isolated portions of protoplasm could still form membranes. Later observers claimed that the non-nucleate fragments might still be connected with nucleated portions of the protoplasm by connecting fibers. Studies of the rhizoids of *Marchantia polymorpha* and the stinging hairs of *Urtica dioica* bring PALLA[25] to reassert his original view that non-nucleate portions of protoplasm can form membranes. He admits, however, that the portions of protoplasm must contain, as reserve substance, a material which can be used in building up a wall.—CHARLES J. CHAMBERLAIN.

South African cycads.—PEARSON[26] has begun the publication of a series of field notes on South African cycads, which promise to be of great interest. The first paper deals with *Encephalartos Friderici Guilielmi*, *E. Altensteinii*, *E. villosus*, and an unnamed species of Stangeria. A summary of the observations is as follows: subterranean branching is a marked feature of the first-named species and of Stangeria; in the first two species of Encephalartos the strobili are lateral, occurring in cycles of three to six about the vegetative apex, which continues the growth of the stem; there is evidence that strobili are produced much more freely in exposed than in shaded situations; it is probable that entomophily occurs in *E. villosus*.—J. M. C.

Apogamy in Elatostema.[27]—TREUB adds *Elatostema acuminatum* (Urticaceae) to the increasing list of plants in which apogamy has been described.

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[23] HILL, T. G., On secondary thickening in recent Pteridophyta. New Phytologist **5**:208–214. 1906.

[24] JEFFREY, E. C., The development, structure, and affinities of the genus Equisetum. Mem. Boston Soc. Nat. Hist. **5**:155–190. *pls. 26–30*. 1899.

[25] PALLA, E., Ueber Zellhautbildung kernloser Plasmateile. Ber. Deutsch. Bot. Gesells. **24**:408–414. *pl. 19*. 1906.

[26] PEARSON, H. H. W., Notes on South African Cycads. I. Trans. S. African Phil. Soc. **16**:341–354. *pls. 6–8*. 1906.

[27] TREUB, M., L'apogamie de l'*Elatostema acuminatum* Brogn. Ann. Jard. Bot. Buitenzorg **20**:141–152. *pls. 4–11*. 1906.

The early stages in the development of megaspores and also in the germination of the megaspore are normal; but a typical egg apparatus is not differentiated. The evidence that embryos are formed without fertilization is conclusive, but the evidence that some of the embryos may not come from nuclear tissue is not so conclusive. TREUB claims that the embryos come from contents of the embryo sac, but not from the egg, and consequently he uses the term apogamy rather than parthenogenesis.—CHARLES J. CHAMBERLAIN.

Anatomical classification of ferns.—FERNAND PELOURDE[28] has attempted to discover an anatomical basis of classification for the ferns. A great amount of detailed structure is described, and, like every other attempt to use one kind of character, the result is a readjustment of some of the old taxonomic lines. The genera represented in France are described upon this new basis, but its application to a wider range of forms remains to be demonstrated. As an addition of certain characters, to be used in connection with all other available characters, the research is a contribution; but as presenting a set of determining characters it can hardly be accepted at this late day.—J. M. C.

Nomenclature of desmids.—NORDSTEDT[29] has proposed the following rules of nomenclature for the desmids: (1) The nomenclature begins with RALFS, *British Desmidieae*, 1848; (2) The authors of names given earlier and accepted by RALFS must always be cited. It is also suggested that standard works for other groups of algae may be used in the same way, as for instance: HIRN, *Monographie und Iconographie der Oedogoniaceen*, 1900; BORNET et FLAHAULT, *Revision des Nostocacées hétérocystées contenues dans les principaux herbiers de France*, 1886–88; GOMONT, *Monographie des Oscillariées* (*Nostocacées homocystées*), 1893.—J. M. C.

Chestnut disease.—In two additional papers MURRILL[30] emphasizes the unusual destructiveness of a disease of the American chestnut first made known by him. This disease is so virulent that it threatens to destroy all the chestnut trees in New York City and perhaps over large areas. The cause of the trouble is a species of Diaporthe newly described as *D. parasitica*. From observations and from experiments it is evident that the fungus attacks the trees only by the way of wounds. Attempts to infect young uninjured twigs and unfolding leaves gave negative results. No satisfactory treatment has as yet been found.—H. HASSELBRING.

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[28] PELOURDE, FERNAND, Recherches anatomique sur la classification des fougères de France. Ann. Sci. Nat. Bot. IX. **4**:261–372. *figs. 80.* 1906.

[29] NORDSTEDT, C. F. O., The starting point of the nomenclature of desmids. Botaniska Notiser **1906**:97–118.

[30] MURRILL, W. A., A new chestnut disease. Torreya **6**:186–189. 1906.

———, Further remarks on a serious chestnut disease. Jour. N. Y. Bot. Garden **7**:203–211. *figs. 25–30.* 1906.

Bulbils and proembryo of Lamprothamnus.—Miss McNICOL[31] has been cultivating *Lamprothamnus alopecuroides*, one of the Characeae, for several years, the plants producing an abundant supply of antheridia and oogonia. Very few of the oospores seemed capable of germination, and proembryos produced from them resemble those produced from the underground nodes. For the most part, reproduction takes place by means of proembryos that are formed on the rhizoid-nodes and make use of the starch stored in the tubercles, which arise either directly or as transformed rhizoids.—J. M. C.

Semipermeable membrane of grass seeds.—BROWN[32] has published a preliminary account of a semipermeable membrane which incloses the grain of Hordeum, which permits the passage of water and iodin, but prevents the passage of sulfuric and hydrochloric acids and all salts of metals examined, when in aqueous solution. The semipermeable property is not due to the action of living protoplasm and is located in the "spermoderm" of the grain. The same covering occurs in grains of Avena, Triticum, and Secale. If these observations are correct, the "spermoderm" is a most remarkable structure.—J. M. C.

Synapsis and synizesis.—Following McCLUNG, SCHAFFNER[33] uses the term synizesis to describe the familiar contracted condition of the chromatin usually described as synapsis; while he reserves the term synapsis in a very restricted sense as applying to the chromatin fusions which take place during the contracted state. The synizetic knot is not always around or in contact with the nucleolus, and while usually lateral it is often central in position. SCHAFFNER'S figures show that the synizetic knot has no relation to gravity.—CHARLES J. CHAMBERLAIN.

Excentric growth.—URSPRUNG[34] records experiments calculated to throw some light on the cause of excentric growth of stems. Seedlings of Ricinus fixed in a horizontal position showed an excentric growth of the hypocotyl, with mechanical cells in the upper part and large thin-walled cells in the lower part. The reason for these appearances is not clear, for it has been shown that mere tension, such as would result in the present instance from the turgescence of the cells on the lower side, does not result in the production of mechanical tissue.—M. A. CHRYSLER.

Growth of lignified cell walls.—It is usually assumed that lignified cell walls, such as those of tracheids, are incapable of further growth. But this idea

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[31] McNICOL, MARY, The bulbils and proembryo of *Lamprothamnus alopecuroides* A. Braun. Annals of Botany **21**:61–70. *pl. 8.* 1907.

[32] BROWN, A. J., On the existence of a semipermeable membrane enclosing the seeds of some of the Gramineae. Annals of Botany **21**:79–87. 1907.

[33] SCHAFFNER, J. H., Synapsis and synizesis. Ohio Naturalist **7**:41–48. *pl. 4.* 1907.

[34] URSPRUNG, A., Beitrag zur Erklärung des excentrischen Dichenwachstums an Krautpflanzen. Ber. Deutsch. Bot. Gesells. **24**:498–501. 1906.

is negatived by the observation of URSPRUNG[35] that the pith of such plants as Sambucus and Tectona increases considerably in diameter after the wood cylinder is formed. This can be brought about only by expansion and division of the elements of the wood. The author holds that vessels can increase in diameter after they have lost their living contents.—M. A. CHRYSLER.

Waterbloom.—MÖBIUS[36] reports that for several years a waterbloom has appeared each summer in the botanical garden in Frankfurt, and that it is regularly composed of three species of Cyanophyceae: *Oscillatoria Agardhii* Gomont, *Anabaena flos-aquae* Bréb., and *Clathrocystis aeruginosa* Henfrey. The appearance of Oscillatoria in the association has not been noted hitherto. An abnormal form of *Cladophora crispata* (Roth.) Kütz. is also described.—CHARLES J. CHAMBERLAIN.

Abnormal mosses.—Two interesting abnormalities are described by GYÖRFFY,[37] collected in the High Tatra. A specimen of *Plagiobryum demissum* Lindb. shows the seta forking at the apex and carrying two perfect capsules; and one of *Polytrichum alpinum* L. has two setae, each carrying a normal capsule, both covered by a single calyptra. BRUCH records a like case in *P. juniperinum*. Obviously these forms have arisen from a single egg.—C. R. B.

Respiration.—KOSTYTSCHEW declares that in the aerobic respiration of the leaves of seed plants which contain mannit, hydrogen is produced; but in anaerobic respiration, even when very vigorous, not a trace is set free.[38] The experiments were designed to test the results of MUNTZ (1876) and DELUCA (1878), which antedated bacteriological knowledge, that H is produced by mannitiferous fungi and seed plants in anaerobic respiration.—C. R. B.

Anatomy of Urticaceae.—RENNER[39] has published a detailed account of the anatomy of Artocarpeae and Conocephaleae, paying special attention to Ficus. A systematic presentation of the tribes follows, the anatomical structure being used as a basis of discussion.—J. M. C.

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[35] URSPRUNG, A., Ueber die Dauer des primaren Dichenwachstums. Ber. Deutsch. Bot. Gesells. **24**:489–497. 1906.

[36] MÖBIUS, M., Algologische Beobachtungen über eine Wasserblüthe und eine Cladophora. Hedwigia **46**:279–287. 1907.

[37] GYÖRFFY, I., Bryologische Beiträge zur Flora der Hohen Tatra. IV. Hedwigia **46**:262. 1907.

[38] KOSTYTSCHEW, S., Zur Frage über die Wasserstoffausscheidung bei der Atmung der Samenpflanzen. Ber. Deutsch. Bot. Gesells. **24**:436–441. 1906.

[39] RENNER, OTTO, Beiträge zur Anatomie und Systematik der Artocarpen und Conocephaleen, insbesondere der Gattung Ficus. Bot. Jarb. **39**:319–448. 1907.

NEWS

DR. JOHN W. HARSHBURGER has been promoted to be assistant professor of botany at the University of Pennsylvania.

INFORMATION has come from Kew that in its future publications the nomenclature will be in accord with the rules adopted by the Vienna Congress.

DR. J. C. ARTHUR, Purdue University, gave an illustrated lecture March 30 in the Field Museum (Chicago) Spring lecture course, his subject being "A superposed vegetation—the plant rusts."

DR. EDWIN B. COPELAND returned from Manila about the middle of March and has taken up research work in plant physiology at the Agricultural Experiment Station of the University of West Virginia, at Morgantown.

THE HOUSE of PAUL PAREY in Berlin has recently issued five new plates of the well-known series by Dr. L. KNY. The new plates are the first of a second hundred, which are to be increased in size from 67×82^{cm} to 106×150^{cm}. They illustrate Drosera, Mimosa, Spirogyra, Cuscuta, and Berberis.

OTTO KUNTZE died suddenly at San Remo on January 28, at the age of 64. His earliest work as a taxonomist appeared in 1867; but since the appearance of his *Revisio Generum* (1891–98) he has been known chiefly for his writings on nomenclature. The *Journal of Botany* justly says: "It is in connection with the revision of nomenclature that his name will chiefly be remembered, and it is to be regretted that the intolerance of his views and the intemperance of the language in which they were stated led to a somewhat insufficient appreciation of his labor and research."

THE UNIVERSITY OF MINNESOTA has recently completed, at a cost of $10,000, a range of plant houses covering about 370 square meters, and consisting of five connected houses and a work room (5×7.5^{m}) with basement for heating apparatus. There is a xerophyte house (7.5×7.5^{m}), palm house ($8.5\times10\times5.5^{m}$ high), aquatic house (5.5×10^{m}), lily house (5.5×10^{m}), and a temperate house. An additional sum of $7000 has been asked to build a laboratory greenhouse connected with the others and to improve the grounds as a botanic garden. Unfortunately the plant houses and grounds are widely separated from the laboratories.

AT THE thirty-seventh annual meeting of the Wisconsin Academy of Sciences, Arts, and Letters held at Madison, Wisconsin, February 7 and 8, 1907, the following botanical papers were presented: E. W. OLIVE: Nuclear migrations and cell fusions in the rusts; A. H. CHRISTMAN: The morphology of the spore forms of the rusts; R. A. HARPER: Heredity in the lower fungi; J. B. OVERTON: Diakinesis in Thalictrum; W. G. MARQUETTE: Concerning the organization of the cell in Marsilia; B. F. LUTMAN: Cell and nuclear fusions in the promycelial cells of certain smuts; C. E. ALLEN: The distribution of grandparental characters in Pisum.